START

0039036

DOE/RL-94-59
Draft A

100-BC-5 Operable Unit Focused Feasibility Study Report

United States
Department of Energy
Richland, Washington

Approved for Public Release

THIS PAGE INTENTIONALLY
LEFT BLANK

DOE/RL-94-59

Draft A

100-BC-5 Operable Unit Focused Feasibility Study Report

Date Published
October 1994

United States
Department of Energy

P.O. Box 550
Richland, Washington 99352

Approved for Public Release

THIS PAGE INTENTIONALLY
LEFT BLANK

THIS PAGE INTENTIONALLY
LEFT BLANK

EXECUTIVE SUMMARY

This focused feasibility study (FFS) report presents the detailed analysis of alternatives for both interim remedial measures (IRM) and potential future actions for the 100-BC-5 Operable Unit. The limited field investigation recommended that the operable unit be removed from the IRM pathway as defined in the *Hanford Past-Practice Strategy* (DOE-RL 1991a). By agreement among the operable unit managers, the FFS was initiated in support of a final action. However, in the course of evaluating alternatives, it was recognized that the data were insufficient to support a final action. Consequently, the unit managers decided to complete the document as an interim FFS to document the modeling and evaluation efforts done to date. Based on current knowledge, the potential contaminant of interest in the operable unit for a final action would be strontium-90 which has a calculated incremental cancer risk (ICR) of 2E-06 based on an occasional-use exposure scenario and which exceeds the Safe Drinking Water Act maximum contaminant level of 8 pCi/L in the near-river wells. The modeling to support the evaluation of alternatives was conducted using strontium-90 data from groundwater monitoring wells in the operable unit.

Chromium and aluminum slightly exceeded ecological benchmark values; however, more recent sampling has shown the levels to be even lower. Ecological hazard quotients were estimated using maximum concentrations from near river wells with no consideration for mixing of the contaminants at the interface of the groundwater and the river. Due to the limited extent of these contaminants and the relatively low levels, the LFI concluded that no IRM was warranted for the operable unit. Therefore, this report does not support interim action nor does it completely support a final action. The report should be considered a forward looking document in support of a future final action for the operable unit.

The 100-BC-5 Operable Unit is one of three operable units associated with the 100 B/C Area of the Hanford Site. Two of the 100 B/C operable units (100-BC-1 and BC-2) are source units. The 100-BC-5 Groundwater Operable Unit includes the groundwater beneath the source operable units and the adjacent groundwater, surface water, fluvial sediments, and aquatic biota impacted by the overlying source operable unit.

The key assumptions which form the basis for the FFS are as follows:

- The purpose of the IRM is to address an identified threat to human health or the environment.
- The objectives of the FFS are to protect the Columbia River and to abate offsite migration of contaminants.
- To meet the objectives, the alternatives are aimed at containment and control of contaminant plumes. (The alternatives are not designed for mass reduction or aquifer cleanup.)
- The occasional-use scenario is assumed for the operable unit.

- For purposes of cost estimates, the FFS uses a finite lifecycle for the IRM to the year 2008. At this time it is assumed that any final action will be implemented, be it a continuation of the IRM or a redirection of the action.

- The *100 Area Feasibility Study Phases 1 & 2* (DOE-RL 1994a) forms the basis for the alternatives evaluated in the FFS. Additional alternatives or deviations from the alternatives are only considered when the defined alternative does not meet the operable unit specifics. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) does, however, allow the flexibility of specifying different process options at any point in the remedial investigation/feasibility study process if warranted by site circumstances.

- Disposal to the Environment Restoration Disposal Facility is assumed for all solid wastes generated. This includes the assumption that sufficient space is available and that the facility will be operating on a schedule consistent with the IRM.

Based on the qualitative risk assessment performed for the operable unit, analysis under the occasional-use scenario resulted in the identification of strontium-90 as a human health contaminant of potential concern (COPC); however, it should be noted that the COPC had a low incremental cancer risk ($<$ 1E-4). Therefore, the COPC does not represent an unacceptable human health risk under this exposure scenario.

Ecological scenarios were evaluated using biological receptors which live in or near the Columbia River. The ecological risk assessment identified potential risks from aluminum and chromium based on exceedances of Ambient Water Quality Criteria. These exceedances were based on the maximum concentrations detected in the near river wells. No allowance was made for environmental attenuation of the contaminants, such as mixing. These constituents were not identified in the river; the concentrations are significantly reduced by the mixing and dilution action of the river.

Based on an additional analysis of the data, chromium is identified as the contaminant of concern (COC) for the operable unit. In the context of FFS, COC are those constituents that must be addressed by remedial actions.

The FFS process includes an evaluation of remedial action objectives (RAO). The RAO are medium-specific or operable unit-specific objectives for protecting human health and the environment. The RAO are based on the land-use, COC, applicable or relevant and appropriate requirements (ARAR), and exposure pathways and include specific remediation goals so that an appropriate range of remedial options can be developed for analysis.

The RAO for environmental protection are:

- control groundwater movement to minimize release of COC from groundwater to surface water that would result in concentrations in the river in excess of Ambient Water Quality Criteria

- prevent destruction of critical habitat; minimize destruction of noncritical habitat; prevent adverse impacts to threatened or endangered species

- prevent erosion of soil during remediation that would contribute to surface water concentrations greater than the Ambient Water Quality Criteria for the COC in surface water.

The preliminary remediation goal (PRG) is 50 μg/L measured in two consecutive sampling rounds in the near-river wells as established in the Tri-Party Agreement Change Control Form M-15-93-02 (Ecology et al. 1994). Chromium concentrations below the chronic Ambient Water Quality Criterion of 11 μg/L as measured in the substrate are considered alternate PRG. These PRG represent screening criteria for the FFS. Final remediation goals will be set in the record of decision.

In the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a), alternatives were developed and screened for the 100 Area as a whole. The FFS modifies these alternatives to meet site-specific conditions. The alternatives considered in the FFS are:

- GW-1 - no action
- GW-2 - institutional controls/continued current actions
- GW-3 - containment
- GW-4 - in situ treatment
- GW-5 - removal, treatment, disposal using ion exchange
- GW-6 - removal, treatment, disposal using reverse osmosis.

Table ES-1 lists the processes included in each alternative. Alternative GW-4 was not considered in the FFS because this alternative applies to organic contaminants and nitrate, neither of which are COC for the operable unit.

The alternatives are defined in detail in the FFS to facilitate the detailed analysis. The detailed analysis is presented in tables where each alternative is compared to seven of the nine CERCLA criteria. These criteria are as follows:

- overall protectiveness
- compliance with ARAR
- long-term effectiveness
- reduction of toxicity, mobility, or volume
- short-term effectiveness
- implementability
- cost.

The comparative analysis uses the results of the detailed analysis to compare alternatives to each other for their relative ability to meet the CERCLA criteria. The results of the detailed and comparative analyses are summarized in Figure ES-1. The FFS will support the proposed plan for the IRM in the operable unit.

Figure ES-1 Summary of Comparative Analysis

Evaluation Criteria	100-BC-5 Groundwater Operable Unit — Alternatives[1]				
	GW-1	GW-2	GW-3	GW-5	GW-6
Overall Protection of Human Health and Environment	●	●	◕	◕	◕
Compliance with ARAR[2]	◔	◔	◔	◔	◔
Long-Term Effectiveness and Permanence	◑	◑	◕	●	●
Reduction of Toxicity, Mobility, and Volume	◑	◑	◕	●	●
Short-Term Effectiveness	●	●	◔	◑	◑
Implementability	●	●	○	◑	◔
Present Worth ($ millions)	0	2.5	16.6	88.7	81.0

Notes:

1. Alternatives are summarized as follows:
   - GW-1 No Interim Action
   - GW-2 Institutional Control
   - GW-3 Containment
   - GW-5 Removal/Ion Exchange Treatment/Disposal
   - GW-6 Removal/Reverse Osmosis Treatment/Disposal
2. ARAR - applicable or relevant and appropriate requirement

Note: GW-4 (In Situ Treatment) was not evaluated.

Key:

- ● Best
- ◕ Better
- ◑ Good
- ◔ Fair
- ○ Poor

E940829.6a

Table ES-1 Alternatives and Process Options

ALTERNATIVE	PROCESSES
GW-1: No Action	Groundwater monitoring
GW-2: Institutional Controls/ Continued Current Actions	Access restrictions Groundwater monitoring Evaluation of results of current actions - pilot-scale treatability test - Columbia River Comprehensive Impact Evaluation - river/groundwater interaction studies - chromium speciation studies - source remediation
GW-3: Containment	Extraction wells
GW-5: Removal, Treatment, and Disposal Using Ion Exchange	Removal - extraction wells Physical treatment: - filtration - ion exchange Stabilization/solidification: - cement-based solidification Liquid disposal: - river discharge or injection into an aquifer Solids disposal: - ERDF, W-025, or other site Monitoring
GW-6: Removal, Treatment, and Disposal Using Reverse Osmosis	Removal: - extraction wells Physical treatment: - filtration - reverse osmosis - forced evaporation Stabilization/solidification: - cement-based solidification Liquid disposal: - crib disposal - river disposal - injection to aquifer Solids disposal: - ERDF, W-025, or other site Monitoring

ERDF - Environmental Restoration Disposal Facility

ACRONYMS

ARAR	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminants of concern
COPC	contaminants of potential concern
CRCIA	Columbia River Comprehensive Impact Assessment
CSCF	continuously stirred continuous flow
CSTR	continuously stirred-tank bioreactors
DF	decontamination factor
DOE	U.S. Department of Energy
DOT	Department of Transportation
Ecology	Washington State Department of Ecology
EHQ	environmental hazard quotient
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
ERDF	Environmental Restoration Disposal Facility
FBR	fluidized-bed bioreactors
FFS	focused feasibility study
FS	feasibility study
GRA	general response actions
HCRL	Hanford Cultural Resources Laboratory
HFSUWG	Hanford Future Site Uses Working Group
HI	hazard index
HRA-EIS	Hanford Remedial Action Environmental Impact Statement
HQ	hazard quotient
HSRAM	Hanford Site Risk Assessment Methodology
ICR	incremental cancer risk
IRM	interim remedial measures
LFI	limited field investigation
MCL	maximum contaminant level
meq/mL	milliequivalent per milliliter
MOC	method of characteristics
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	operation and maintenance
OTD	Office of Technology Development
PNL	Pacific Northwest Laboratories
QRA	qualitative risk assessment
RAGS	Risk Assessment Guidance of Superfund
RAO	remedial action objective

ACRONYMS (cont)

RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SF	slope factor
SVE	soil vapor extraction
TBC	to-be-considered
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
UCL	upper confidence level
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

CONTENTS

CONTENTS (cont)

CONTENTS (cont)

CONTENTS (cont)

FIGURES:

CONTENTS (cont)

FIGURES (cont):

TABLES:

CONTENTS (cont)

TABLES (cont):

1.0 INTRODUCTION

This focused feasibility study (FFS) report is in support of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) remedial investigation/feasibility study (RI/FS) activities for the 100-BC-5 Groundwater Operable Unit. The RI/FS process is described in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988). This focused feasibility study (FFS) report presents the detailed analysis of alternatives for both interim remedial measures (IRM) and potential future actions for the 100-BC-5 Operable Unit. The limited field investigation recommended that the operable unit be removed from the IRM pathway as defined in the *Hanford Past-Practice Strategy* (DOE-RL 1991a). By agreement among the operable unit managers, the FFS was initiated in support of a final action. However, in the course of evaluating alternatives, it was recognized that the data were insufficient to support a final action. Consequently, the unit managers decided to complete the document as an interim FFS to document the modeling and evaluation efforts done to date. Based on current knowledge, the potential contaminant of interest in the operable unit for a final action would be strontium-90 which has a calculated incremental cancer risk (ICR) of 2E-06 based on an occasional-use exposure scenario and which exceeds the Safe Drinking Water Act maximum contaminant level of 8 pCi/L in the near-river wells. The modeling to support the evaluation of alternatives was conducted using strontium-90 data from groundwater monitoring wells in the operable unit.

Chromium and aluminum slightly exceeded ecological benchmark values; however, more recent sampling has shown the levels to be even lower. Ecological hazard quotients were estimated using maximum concentrations from near river wells with no consideration for mixing of the contaminants at the interface of the groundwater and the river. Due to the limited extent of these contaminants and the relatively low levels, the LFI concluded that no IRM was warranted for the operable unit. Therefore, this report does not support interim action nor does it completely support a final action. The report should be considered a forward looking document in support of a future final action for the operable unit.

The 100 Area is one of four areas on the Hanford Site that are on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL) under CERCLA (Figure 1-1). The 100-BC-5 Operable Unit is one of three operable units associated with the 100 B/C Area at the Hanford Site (Figure 1-2). Two of the 100 B/C Area operable units are source operable units and one is a groundwater operable unit. The 100-BC-1 Operable Unit includes the liquid and sludge disposal sites generally associated with operation of the B Reactor. The 100-BC-2 Operable Unit includes the C Reactor and its associated facilities, the burial grounds south of the C Reactor, and the solid waste facilities northeast of the B Reactor. The 100-BC-5 Groundwater Operable Unit includes the groundwater below the source operable units plus the adjacent groundwater, surface water, sediments, and aquatic biota impacted by the 100 B/C Area operations.

The approach for the RI/FS activities for the 100 Area operable units has been further defined in the *Hanford Past-Practice Strategy* (DOE-RL 1991a). This strategy streamlines the past-practice remedial action process with a bias for action through optimizing the use of interim remedial measures (IRM) and expedited response actions (ERA).

All work conducted at the 100 Area waste sites is in accordance with the conditions set forth in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) and its amendments, signed by the Washington Department of Ecology (Ecology), EPA, and the U.S. Department of Energy (DOE).

1.1 PURPOSE AND SCOPE

The *Hanford Past-Practice Strategy* (DOE-RL 1991a) defines the FFS as an evaluation of a limited number of alternatives that are focused to the scope of the response action planned. The FFS constitutes the detailed analysis phase which completes the FS evaluation process for the targeted IRM. In addition to the screened alternatives evaluated in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a), the detailed analysis phases integrate the results of areawide studies such as river impact, shoreline, ecological, cultural resources, treatability, and background studies as well as information from operable unit-specific limited field investigations (LFI) and qualitative risk assessments (QRA).

The FFS does the following things:

- updates and refines remedial action objectives (RAO), contaminants of concern (COC), applicable or relevant and appropriate requirements (ARAR), and remedial alternatives based on new information developed since the development of the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a) (additional risk assessment may be used to refine RAO and COC)

- performs detailed and comparative analysis of IRM alternatives.

The FFS is performed primarily to provide a detailed analysis of remedial action alternatives for sites remaining on the IRM pathway as identified in the operable unit-specific LFI reports.

The objective of the FFS is to provide decision makers sufficient information on waste site conditions and remedial alternatives to allow them to make an appropriate and timely decision on remediation of sites to be addressed through IRM. The FFS evaluates alternatives identified in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a) and considers new information on technologies, operable unit characteristics, and area wide studies.

The 100-BC-5 Operable Unit represents a special case because the LFI did not recommend keeping the operable unit on the IRM pathway. However, the operable unit managers agreed to proceed with the FFS to document the applicable alternatives and to meet previously agreed upon milestones.

Concurrently, FFS are being prepared for some of the 100 Area source operable unit. Source remediation is integral to successful remediation of groundwater; therefore, the remediation of groundwater is closely tied to the remediation of the sources of contamination. The source FFS currently under preparation are aimed at the high priority sites, mainly the liquid waste sites. Remediation of these sites will likely play a major role in remediation of the groundwater by eliminating a pathway for continued contamination.

1.2 REPORT ORGANIZATION

The FFS is organized into the following sections:

- Section 1.0 - introduction and discussion of purpose of report and summaries of 100 Area studies that support the FFS.
- Section 2.0 - operable unit background and summaries of operable unit-specific reports.
- Section 3.0 - discussion of RAO including land use, COC, ARAR, and remediation goals.
- Section 4.0 - detailed descriptions of the groundwater remedial alternatives identified in the 100 Area FS including any modifications to the alternatives based on new information concerning contaminants or technologies; discussion of uncertainties associated with the alternatives.
- Section 5.0 - discussion of modeling efforts for FFS.
- Section 6.0 - discussion of detailed analysis methodology; detailed analysis tables comparing each alternative to the CERCLA nine criteria.
- Section 7.0 - discussion of sensitivities associated with the key assumptions for the FFS.
- Section 8.0 - comparative analysis of alternatives using the CERCLA nine criteria.
- Appendix A - data evaluation for supplemental risk assessment.
- Appendix B - supplemental risk assessment.
- Appendix C - ARAR.
- Appendix D - general detailed alternative descriptions.
- Appendix E - cost models.

1.3 SUMMARY OF THE HANFORD PAST-PRACTICE STRATEGY

The strategy streamlines the past-practice remedial action process with a bias for action through the use of ERA and IRM. The strategy focuses on reaching early decisions to initiate and complete remedial projects and maximizing the use of existing data, coupled with focused, short time-frame investigations where necessary.

Figure 1-3 depicts the interrelationships and sequencing of steps and activities that must be integrated to bring an operable unit from field investigation through record of decision (ROD). The diagram is consistent with the approach outlined in the *Hanford Past-Practice Strategy* (DOE-RL 1991a). This figure provides a graphical description of the entire process of characterization activities, risk assessments, treatability studies, and FS for the high and low priority sites within an operable unit and for the operable unit as a whole. Each of the figure elements and their interrelationships are described in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a).

1.4 SUMMARY OF 100 AREA FEASIBILITY STUDY PHASES 1 AND 2

The 100 Area Phase 1 and 2 FS provided an evaluation of the known 100 Area characteristics and identified the range of remedial alternatives that are most appropriate for protection of human health and the environment for the entire aggregate area. The purpose of the 100 Area FS was to:

- provide a generalized view of applicable and workable remedial technologies as applied to the site contamination problems as a whole
- evaluate groups of sites based on similarity, as opposed to geographical location and operable unit designation
- develop and screen remedial alternatives to be used in the detailed analysis phase of the FFS for IRM or final FS for individual operable units.

The 100 Area Phase 1 and 2 FS consisted of four principal tasks:

- identify COC for the media of concern
- identify ARAR pertinent to all general response actions
- develop remedial alternatives (Phase 1) applicable to the 100 Area including development of remedial action objectives, development of general response actions, identification and screening of technologies and process options, and assembly of remedial alternatives from representative technology types
- screen alternatives (Phase 2) developed in Phase I for implementability, effectiveness, and costs to identify those alternatives that warrant advancement to the detailed analysis phase of future FFS.

General response actions (GRA) and alternatives retained as a result of Phases 1 and 2 are evaluated in detail in the FFS. General response actions were identified as follows:

- no action
- institutional actions
- containment actions
- in situ treatment actions
- removal/treatment/disposal actions.

Alternatives retained from Phases 1 and 2 are listed in Table 1-1.

1.5 100 AREA WIDE AND AGGREGATE AREA STUDIES

The 100 Area aggregate studies and Hanford Site studies, such as the Hanford Site background studies, provide integrated analyses of selected issues on a scale larger than an operable unit. The 100 Area work plans (DOE-RL 1992a-d) address studies common to the 100 Area covering topics such as a river impact, shoreline, ecology, and cultural resources. Results of these studies are summarized in the following sections. Details of the studies can be found in the corresponding references.

1.5.1 Hanford Site Background

The natural inorganic chemical composition of groundwater in the unconfined aquifer system beneath the Hanford Site is presented in *Hanford Site Groundwater Background* (DOE-RL 1992e). The characterization effort identifies the types and concentrations of inorganic analytes that exist naturally in the groundwater. Provisional threshold levels for 40 inorganic analytes developed in this effort are listed in the LFI. Background values for most radionuclides and organic constituents have not been developed.

1.5.2 Hanford Remedial Action Environmental Impact Statement

In accordance with DOE Order 5400.4 and Chapter 10 Code of Federal Regulations (CFR) Part 1021, the values of the National Environmental Policy Act (NEPA) of 1969 are to be incorporated in the CERCLA process. Many of the NEPA values are addressed in the detailed analysis of remedial alternatives within this FFS; however, Hanford Site and areawide impacts are addressed by the *Hanford Remedial Action Environmental Impact Statement* (HRA-EIS).

The HRA-EIS analyzes the impacts caused by remediating the CERCLA/Resource Conservation and Recovery Act (RCRA) past-practice waste sites on the Hanford Site. The NEPA strategy follows a tiered approach that allows the issues addressed in the HRA-EIS to be incorporated into subsequent assessments by reference alone (40 CFR 1502.20). A draft of the HRA-EIS was scheduled for public review in August 1994; however, the draft HRA-EIS has been delayed for possibly up to two years. The final ROD for the HRA-EIS is scheduled for April 1995 and will also likely be delayed. In the interim, there is no definitive land-use scenario for the 100 Area.

1.5.3 Ecological Studies

Bird, mammal, and plant surveys were conducted and reported in Sackschewsky and Landeen (1992). Current contamination data has been compiled from other sources, along with ecological pathways and lists of all wildlife and plants at the site, including threatened and endangered species (Weiss and Mitchell 1992). Another report (Caldwell 1994), discusses aquatic species on the Hanford Reach of the Columbia River; mapping activities of vegetation on the site and efforts to survey species of concern; shrub-steppe bird surveys; and mule deer and elk population monitoring. Report conclusions state that intrusive activities, such as remedial actions, that are conducted inside the controlled-area fences will not have a significant impact on the wildlife. Intrusive activities outside the controlled-area fences will have minimal impact on wildlife if the recommendations contained in the three documents listed below are followed (Landeen et al. 1993):

- *Bald Eagle Management Plan* (Fitzner and Weiss 1994)
- *Biological Assessment of Threatened and Endangered Species* (Fitzner et al. 1994).

The ecology of the riverine and riparion zones associated with the Columbia River is summarized in the *Columbia River Impact Evaluation Plan* (DOE-RL 1993a). Additional information sources are included as references in the evaluation plan.

The DOE policy also states that site-specific ecological surveys will be conducted at all sites where cleanup and remedial actions are performed.

1.5.4 Groundwater/River Interaction

Several projects are contributing to a better understanding of how contaminated groundwater from the Hanford Site enters the Columbia River along the 100 Areas. This topic was included in an earlier Tri-Party Agreement milestone that addressed 100 Areas general investigations (M-30-00 series). A submilestone required 1) installing equipment and 2) initiating monitoring activities to perform long-term evaluation of river/aquifer interaction; both milestone requirements were completed by September 1993. There are no subsequent milestones, however, to present the results of the evaluation of interaction.

Automated equipment is installed in wells at each reactor area to measure water levels at hourly intervals. Similar stations are operating at four reactor areas to measure river stage changes. Selected stations also contain sensors to record temperature and electrical conductivity. In the 100 H Area, simultaneous recording of water levels, temperature, and conductivity are being made in the nearshore river, in riverbank seepage, and in a shoreline monitoring well. All of these stations will be operated for a time period sufficient to describe daily, weekly, and seasonal river cycles (most stations will have meet this objective by Fall 1994). Operation of the equipment and selected results are described in annual progress reports (e.g. Campbell 1994).

Monitoring activities include data collection by the equipment just described, as well as data collected for operable unit sampling tasks, as listed in work plans. Groundwater, riverbank seepage, and shoreline sediments are all sampled as part of operable unit sampling. Nonenvironmental restoration program activities, such as RCRA groundwater monitoring and sitewide environmental surveillance conducted under DOE Order 5400.1, also contribute data that are relevant to river/aquifer interaction investigations. A summary of water quality data from near-river monitoring wells, riverbank seepage, and nearshore river water is presented in Peterson and Johnson (1992). Riverbank seepage, shoreline sediment, and river water data for sampling activities conducted for the environmental restoration program are published in DOE-RL (1992f) and WHC (1993a). The data are also available from the Hanford Environmental Information System.

Interpretation of river/aquifer interaction data is in progress. Initial results show that groundwater is affected by river stage changes in several ways. River fluctuations can be observed as water level changes in wells throughout the reactor areas, with a time lag and amplitude decrease occurring as the well's distance from the river increases. This information has potential use for inferring aquifer hydraulic properties (e.g. McMahon and Peterson 1992). River stage changes also affect water quality, but only within several hundred feet of the river, and to varying degrees depending on the magnitude and duration of stage changes. Evidence for some degree of groundwater dilution by river water prior to crossing the channel interface is found in river bank seepage concentrations of contaminants. Seepage concentrations are almost always intermediate between values in shoreline wells and nearshore river water (Peterson and Johnson 1992).

An understanding of the physical and chemical environment at the aquifer/river interface, and of the processes occurring at the interface, is fundamental for assessing the impact of Hanford Site groundwater on Columbia River water quality and ecosystems. It is also relevant in assessing the performance of remediation activities. Continued investigation of aquifer/river exchange is strongly encouraged to support future records of decision for environmental restoration.

1.5.5 Investigations of Chromium in Groundwater

An effort is underway to describe how chromium moves with groundwater and where chromium fixation might occur (DOE-RL 1993a). This study of chromium speciation looks at the concentrations and valence state of chromium in the unconfined aquifer, at the interface between the aquifer and the river, and in the nearshore river. Analysis of the various valence states in sediments and periphyton coatings on sediments is included, along with tests involving potential changes in valence state that occurs when groundwater is mixed with river water. Initial interpretations suggest that some hexavalent chromium in groundwater is reduced to the less-toxic and less-mobile trivalent state at the aquifer/river interface.

1.6 SUMMARY OF 100 AREA GROUNDWATER TREATABILITY STUDIES

Treatability tests were conducted on groundwater samples collected from the 100-HR-3 Groundwater Operable Unit to collect data on treatment technologies. The 100-HR-3 Operable Unit consists of the groundwater beneath the 100 H and 100 D/DR Areas; constituents in the operable unit include chromium, nitrate, and uranium. Bench-scale tests of biodenitrification used batch studies to determine if biodenitrification could reduce the nitrate concentration to a residual of <45 mg/L (as NO_3), the current maximum contaminant level (MCL) as defined in the Safe Drinking Water Act (SDWA) (40 CFR 141). The tests were conducted under the *100-HR-3 Groundwater Treatability Test Plan* (DOE-RL 1992f), the *Treatability Study Program Plan* (DOE-RL 1992g), and the *100 Area Groundwater Biodenitrification Bench-Scale Treatability Study Procedures* (Peyton and Martin 1993). The results of the test are presented in *100 Area Groundwater Biodenitrification Bench-Scale Treatability Study -- Final Report* (Peyton 1994).

Treatability tests were also conducted to test the removal of chromate, nitrate, and uranium (VI) using precipitation/reduction and/or ion exchange treatments. The tests are described in the *100-HR-3 Groundwater Treatability Test Plan* (DOE-RL 1992f). Procedures for the tests are specified in *100-HR-3 Area Groundwater Treatment Tests for Ex Situ Removal of Chromate, Nitrate, and Uranium (VI) by Precipitation/Reduction and/or Ion Exchange* (WHC 1993a); results are presented in *Treatment Tests for Ex Situ Removal of Chromate, Nitrate, and Uranium (VI) from Hanford (100-HR-3) Groundwater Final Report* (WHC 1993b). Results of each test are summarized in the following sections.

1.6.1 Precipitation/Reduction

1.6.1.1 Sulfide Precipitation. A ferrous sulfate/sodium sulfide method was tested to first reduce the chromium (VI) to chromium (III) and then to coprecipitate the reduced chromium with the resulting ferric hydroxide and/or ferric sulfide (WHC 1993b). The possible reduction and/or precipitation of uranium was also investigated. The ferrous sulfate/sodium sulfide treatment was effective at removing the chromium (decontamination factor [DF] of 64); however, the treatment failed to remove uranium or nitrate and generated significant quantities of sludge. (The DF is defined as the original concentration of the contaminant divided by the concentration after treatment. A DF <2 is considered insignificant.) The method resulted in a colloidal suspension which was not removed by centrifugation.

1.6.1.2 Brushite Coprecipitation. Disodium hydrogen phosphate was used to precipitate brushite from the contained calcium ion naturally present in the groundwater to determine the potential for removing uranium. The incidental removal of chromate from solution by coprecipitation with brushite was also investigated. The brushite treatment produced significant DF for uranium (DF = 32). This treatment did not result in significant DF (>2) for chromate and had little effect on nitrate concentrations. Because neither precipitation method resulted in removal of both chromate and uranium and because both generated significant quantities of sludge or flocculent, no further tests were conducted.

1.6.2 Ion Exchange

Three different strong-base anion exchange resins were tested based on recommendations of resin manufacturers (Dowex 21K™ from Dow Chemical Company and Amberlite 402™ and 410™ from Rohm and Haas Company). All three resins had excellent DF for uranium (90±70 to 110±70) and chromate (60±46 to 90±12). The Dowex 21K™ had a much higher DF for nitrate (40±20) than the Amberlite 410™ (12±2) or Amberlite 402™ (6±1). The Dowex 21K™ removed the high concentration of contaminants down to the level of detection for several hundred column volumes.

The test was a full factorial experiment, which means that all combinations of the variables of interest were explored. Tests conducted included batch tests, equilibrium tests, and breakthrough tests. Equilibrium tests showed that the adsorption potential for Dowex 21K™ for uranium and chromate was far higher than the amount of groundwater available for spiking.

The following summarizes the results of the batch anion exchange resin test results:

- No pretreatment requirements were identified in the treatability tests; however a prefilter is recommended for field application.
- The optimum resin for treatment of chromate, nitrate, and uranium based on the results of the tests is Dowex 21K™, a strong-base anion exchange resin.
- No breakthrough was observed in water from well 199-H4-4 for chromium or uranium. Nitrate showed breakthrough after 445 column volumes. The concentrations from this well were 84,600 ppb nitrate, 49 ppb uranium, 65.5 ppb chromate, and 79.4 ppb total chromium.
- Breakthrough for water from well 199-D5-15 occurred at 450 column volumes for nitrate and 1,100 column volumes for chromium. Initial concentrations were 49,700 ppb nitrate, 12 ppb uranium, 1,930 ppb chromate, and 2,025 ppb total chromium. Breakthrough for chromium occurred at 100 ppb; therefore, 1925 ppb was taken up by the ion exchange resin. The capacity of the Dowex 21K™ is 2.79 μg chromium per mg of resin based on the test results for this well water.
- No degradation of resin or resin life was noted during multiple cycles.
- During the multiple cycles, the contaminant concentrations were below the performance goals with the exception of uranium. This may not be too significant because the levels of uranium introduced in the test were much higher (8 times) than typical 100 Area groundwater uranium concentrations.
- The ion exchange was eluted with 4 to 5 column volumes of 4 M sodium chloride then washed with one to two column volumes to regenerate the resin for reuse. The concentrations in the eluate were typically several hundred

thousand ppb chromium, ten million ppb nitrate, and thirty thousand ppb uranium. Both the eluate and wash contained uranium and were considered mixed waste.

As part of the breakthrough tests, a low flow rate (16 column volumes per hour [3.4E-4 gal/min]) test using groundwater spiked with 700 ppb uranium, 1,770 ppb chromium (VI), 2,020 ppb total chromium, and 192,300 ppb nitrate showed that 1,800 column volumes were insufficient to show breakthrough for uranium. Chromium concentrations at 1,800 column volumes were near the performance level at 3% to 4% of original concentrations. Nitrate showed breakthrough at 350 column volumes, which corresponds to a resin loading of 1.1 milliequivalents/milliliter (meq/mL) of wet conditioned resin. This loading is very close to the theoretical capacity of 1.2 meq/mL for the Dowex 21K™ resin. (Breakthrough is defined as 50% of the original concentration.)

A high flow rate (27 column volumes per hour [5.7E-4 gal/min]) test using groundwater spiked with 820 ppb uranium, 2,100 ppb chromium, 1,990 ppb chromate, and 212,700 ppb nitrate showed no breakthrough for chromium; however, the test was ended prematurely due to equipment failures. Uranium concentrations were slightly higher in the effluent than in the slow flow rate test which may indicate that the kinetics of uranium adsorption are slow. The uranium concentration was always less than the performance level (22 μg/L).

1.7 PILOT-SCALE TREATABILITY STUDY

Milestone M-15-06E requires that DOE being pilot-scale pump and treat operations for 100-HR-3 Operable Unit by August 1994. The pilot-scale is to address chromium. Assuming the pilot scale is successful, it would continue to operate until the ROD. Full-scale operation would be implemented if it were determined to be the selected remedy under the 100-HR-3 ROD. If the pump and treat operation is the selected remedy under the ROD it would continue until the three parties evaluate the operation using the following criteria:

1) Hexavalent chromium measured in wells near the Columbia River fall below the Model Toxics Control Act (MTCA) standard for chromium of 50 μg/L for two consection sampling periods.

2) Sampling of water occurring in the river bottom substrate environment, where springs are suspected to discharge contaminated groundwater, in concentrations representative of the plume, indicates that hexavalent chromium in this environment is below and will remain below the chronic Ambient Water Quality Criterion for the protection of freshwater aquatic life for hexavalent chromium (11 μg/L) set by the EPA.

3) Groundwater/Columbia River interaction studies, numerical models or physical models indicate that predicted levels of hexavalent chromium within the riverbed substrate environment, where contaminated groundwater is suspected

to discharge, in concentrations representative of the plume, are below the chronic Ambient Water Quality Criterion for the protection of freshwater aquatic life for hexavalent chromium (11 μg/L) set by the EPA.

4) Biological surveys, such as aerial photographic records, of Columbia River sections where contaminated groundwater discharges may reasonably be expected to occur, indicate that contemporary salmonid redd distributions are at concentrations and locations expected if hexavalent chromium were not an influence.

5) The effectiveness (including cost/unit of hexavalent chromium removed) of the treatment technology does not justify further operation.

6) An alternate treatment technique, such as chemical reduction of the hexavalent chromium to a less toxic valence, that is more effective or is less costly is substituted.

Assumptions associated with the Tri-Party Agreement Change Control Form (Ecology et al. 1994) for the pilot-scale treatability test are as follows:

- The LFI activities do not identify hexavalent chromium data inconsistent with data to date.
- The QRA justifies the need for remediation.
- Treated effluent containing contaminants above State water quality standards can be disposed of the soil column or aquifer.
- Hazardous, radioactive and/or mixed waste (e.g. resins) will be stored and/or disposed of on-site at locations as agreed to by the three parties.
- Bench-scale tests will confirm treatment assumptions.
- The pilot-scale treatability test will be performed in accordance with the *100-HR-3 Groundwater Treatability Test Plan* (DOE-RL 1992f).

The *Pilot-Scale Treatability Test Plan for the 100-HR-3 Operable Unit* (DOE-RL 1994b) provides an outline for the pilot-scale test using the Dowex 21K™ resin in an ion exchange pump and treat system.

1.8 KEY ASSUMPTIONS FOR FFS

The key assumptions which form the basis for the FFS are as follows:

- The purpose of the IRM is to address an identified threat to human health or the environment.

- The objectives of the FFS are to protect the Columbia River and to abate offsite migration of contaminants.

- To meet the objectives, the alternatives are aimed at containment and control of contaminant plumes. (The alternatives are not designed for mass reduction or aquifer cleanup.)

- The occasional-use scenario is assumed for the operable unit.

- For purposes of cost estimates, the FFS uses a finite lifecycle for the IRM to the year 2008. At this time it is assumed that any final action will be implemented, be it a continuation of the IRM or a redirection of the action.

- The *100 Area Feasibility Study Phases 1 & 2* (DOE-RL 1994a) forms the basis for the alternatives evaluated in the FFS. Additional alternatives or deviations from the alternatives are only considered when the defined alternative does not meet the operable unit specifics. The CERCLA does, however, allow the flexibility of specifying different process options at any point in the RI/FS process if warranted by site circumstances.

- Disposal to the Environmental Restoration Disposal Facility (ERDF) is assumed for all solid wastes generated. This includes the assumption that sufficient space is available and that the facility will be operating on a schedule consistent with the IRM.

Each of these key assumptions is discussed in Sections 2.0 through 6.0 of the FFS. The sensitivities associated with these assumptions are discussed in Section 7.0.

Figure 1-1 Hanford Site

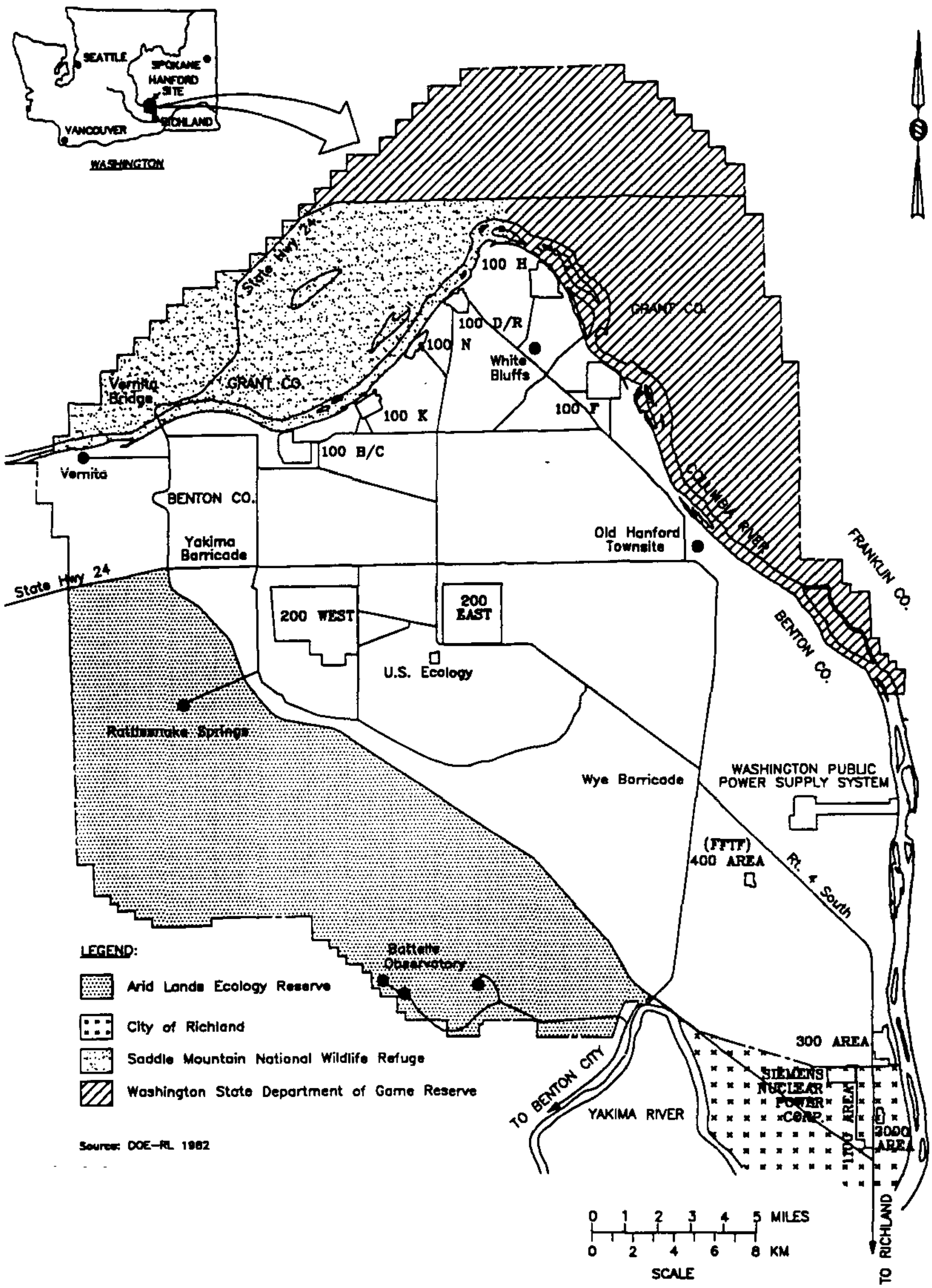
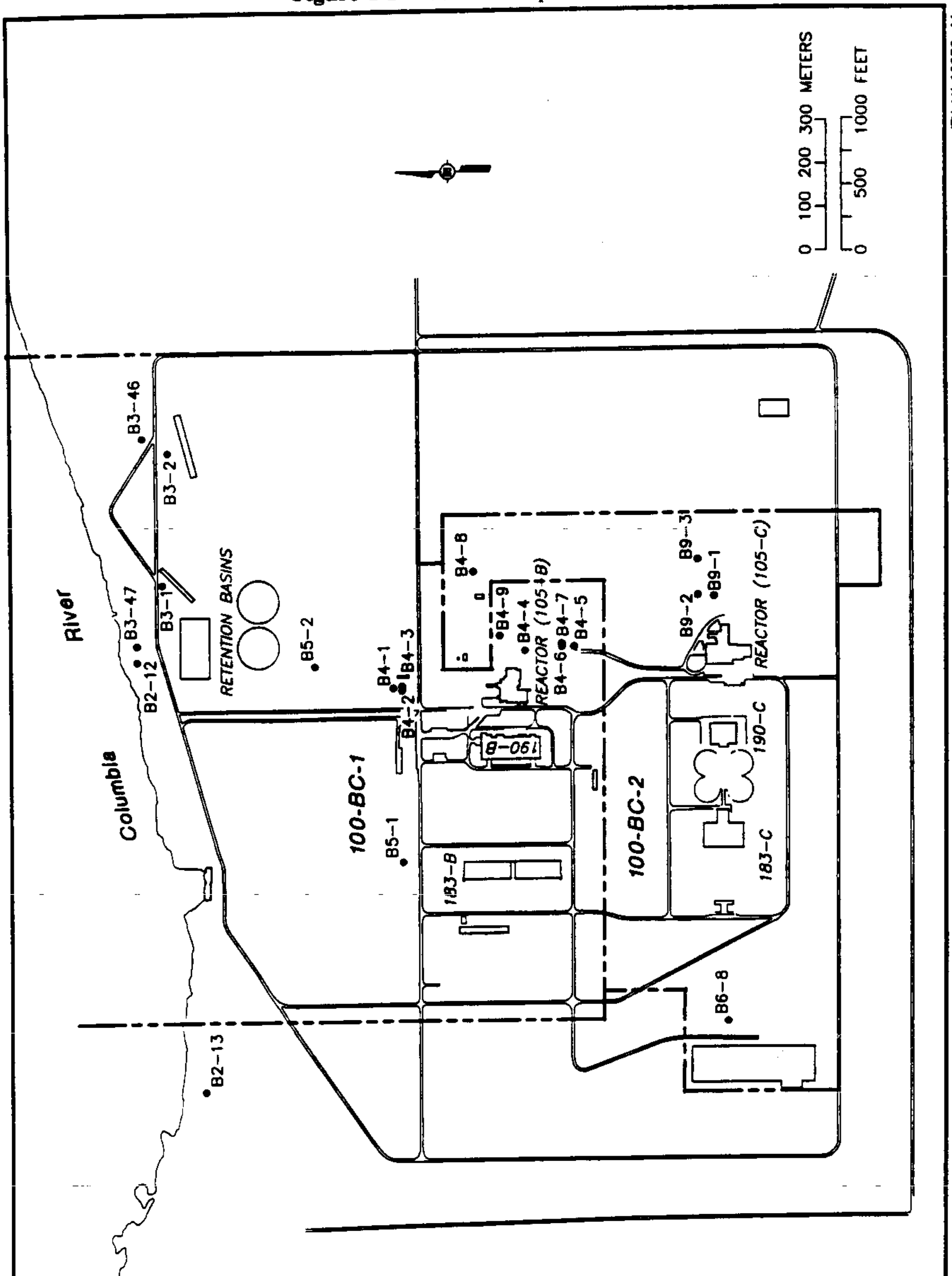


Figure 1-2 100-BC-5 Operable Unit



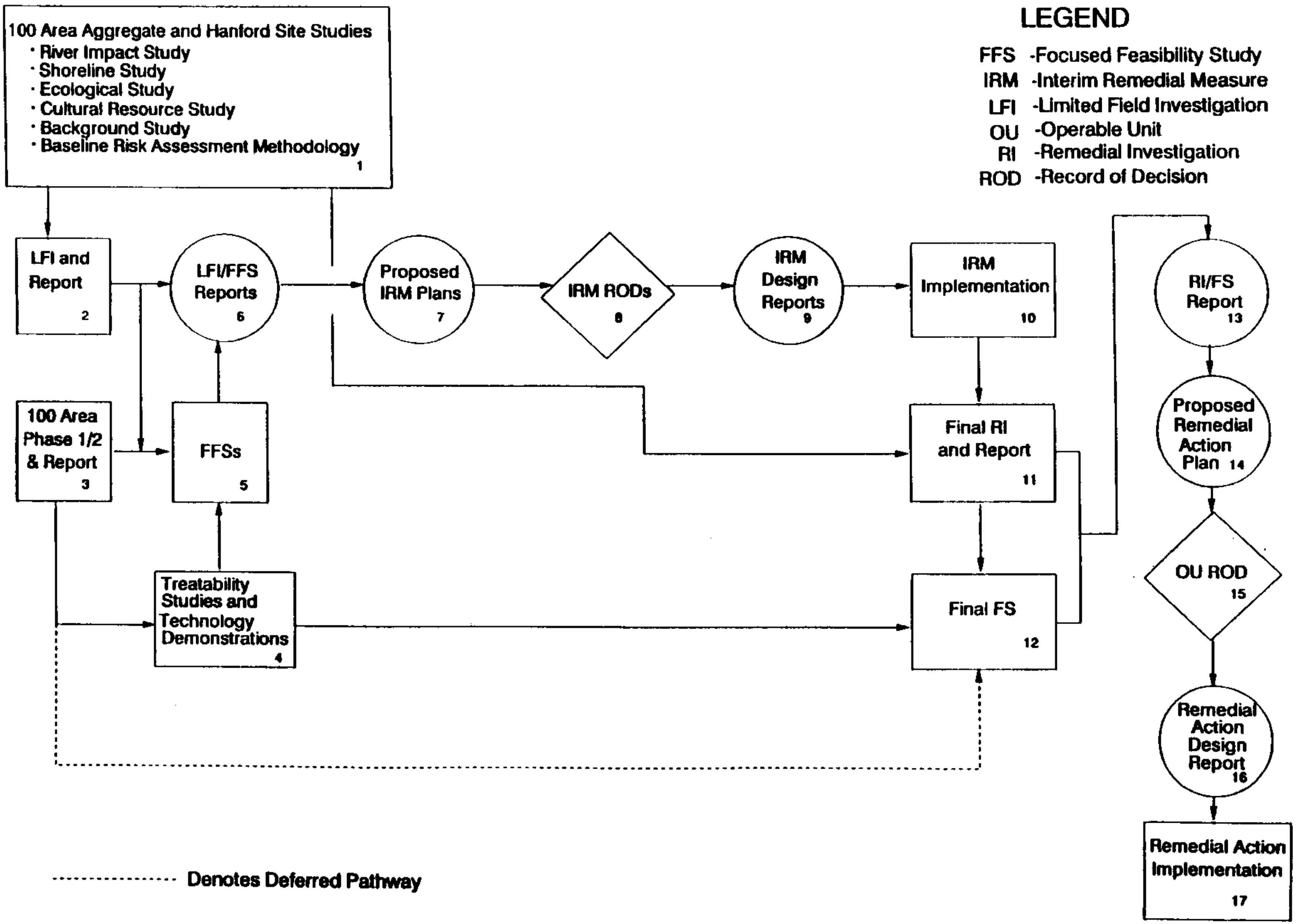


Figure 1-3 Hanford Past-Practice Strategy Diagram

Table 1-1 Alternatives Retained from 100 Area Feasibility Study

Alternative	Description		Recommendation
GW-1	No Action		Retain for detailed analysis and risk assessment data.
GW-2	Institutional:	Water-rights and deed restrictions Groundwater monitoring Columbia River as alternate water supply	Retain to preserve range of GRA to be evaluated in FFS.
GW-3	Containment:	Slurry walls Extraction wells	Retain to preserve range of GRA to be evaluated in FFS.
GW-4	In Situ Treatment:	Biodenitrification Air stripping	Retain as an in situ treatment action.
GW-5	Removal, Treatment, & Disposal:	Extraction wells Biodenitrification Chemical oxidation, precipitation, and chemical reduction Media filtration and ion exchange Cement-based solidification Injection into aquifer ERDF	Retain as a removal, treatment, and disposal action based on chemical treatment processes.
GW-6	Removal, Treatment, & Disposal:	Extraction wells Biodenitrification Air stripping, forced evaporation, media filtration, and reverse osmosis Cement-based solidification Crib disposal, vaults, and trenches/pits ERDF	Retain as a removal, treatment, and disposal action based on physical treatment processes.

GRA = general response action
FFS = focused feasibility study
ERDF = Environmental Restoration Disposal Facility

2.0 OPERABLE UNIT BACKGROUND

The 100-BC-5 Operable Unit is located in the north-central portion of the Hanford Site along the southern shoreline of the Columbia River (see Figures 1-1 and 1-2). The site is approximately 45 km (28 mi) northwest of the city of Richland and encompasses approximately 3.0 km^2 (1.1 mi^2). It lies predominantly within Section 11, the southern portion of Section 2, and the western portion of Section 12 of Township 13N, Range 25E. The 100 B/C Area lies approximately between the north/south Washington State coordinates N143700 and N145500 and east/west coordinates E564200 and E566800. Outfall structures and river effluent pipelines will be addressed by an ERA.

Since the preparation of the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a), additional data has been collected relevant to the 100 Area in general, as well as the 100 B/C Area and the 100-BC-5 Operable Unit specifically. An LFI and QRA were performed for the operable unit and aggregate area studies were performed to evaluate cultural resources, area ecology, and the Columbia River and its sediments.

2.1 LIMITED FIELD INVESTIGATION

As part of the LFI, ten new groundwater monitoring wells were installed in the 100-HR-3 Operable Unit. These wells were constructed to help define groundwater quality:

- in areas of potential public or environmental exposure
- immediately downgradient of priority source operable unit waste sites.

Well locations are shown on Figure 2-1.

Groundwater samples were collected from these wells and existing monitoring wells. Samples were collected over five rounds of sampling. Analyses were conducted for organic, inorganic, and radioactive constituents. Concentrations for strontium-90 and chromium are presented in Figures 2-2 and 2-3. Soil samples were collected during well drilling activities and analyzed for physical properties. The data derived from this sampling and analysis effort were used to perform the QRA (WHC 1993c) and the supplemental risk assessment (Appendix B). Table 2-1 presents the maximum concentrations identified in the 100 B/C Area in the aquifer, in the near-river wells, in the springs and seeps, and in the river. Results of the LFI indicated an IRM for the 100-BC-5 Operable Unit was not warranted. However, the unit managers agreed to proceed with the FFS to document applicable alternatives for any future actions that may be necessary following source remediation and continuing activities.

2.2 CULTURAL RESOURCES REVIEW

In compliance with Section 106 of the National Historic Preservation Act, and at the request of Westinghouse Hanford Company (WHC), the Hanford Cultural Resources

Laboratory (HCRL) conducted an archaeological survey during fiscal year 1991 of the 100 Area reactor components on the Hanford Site (Chatters et al. 1992). This survey was conducted as part of a comprehensive cultural resources review of the 100 Area CERCLA operable units in support of CERCLA characterization activities. The work included a literature and records review and pedestrian survey of the project area following procedures established in the *Hanford Cultural Resources Management Plan* (Chatters 1989).

The 100 B/C Area consists of approximately 441 ha (1089 acres), of which nearly 30% (133 ha [329 acres]) was surveyed. Most of this operable unit is on the gently sloping Pleistocene terrace ranging from 133 m (436 ft) above sea level on the north edge to 153 m (501 ft) above sea level at the southern boundary. The remainder of the area is a steeply sloping bank (1:10, i.e., 10% grade) that extends down to the Columbia River shoreline. An extensive gravel beach is exposed along the north boundary of the operable unit at low water. On the upstream end of the operable unit, the bank is less steep, broadening into a gently sloping (1:50, i.e., 2% grade) gravel flat, 150 m (492 ft) wide. Archeological survey efforts were concentrated along the shoreline and the undisturbed periphery around the reactor complex.

Two archaeological sites (H3-17 and 45BN446) and a single isolated artifact (45BN430) were located within the 100 B/C Area. Site H3-17 is located on the high terraces occupied by the reactor facilities and may be affected by CERCLA activities. Site 45BN446 is at risk because it may be located near frontage roads or launch facilities and may be affected by CERCLA activities. Figure 2-2 shows the areas of the operable unit that have been surveyed for cultural resources.

Evaluation of the significance of all sites discovered in fiscal year 1991 will likely be conducted in the future. The DOE is currently considering negotiating a programmatic agreement with the Washington State Historic Preservation Office, the Advisory Council for Historic Preservation, and affected Native American Tribes to aid in the mitigation of affects to significant historic properties that are within or affected by contamination from CERCLA operable units. All work and road building associated with CERCLA activities in the 100 Area will be reviewed by HCRL and DOE personnel and plans will be adjusted to avoid impacts to cultural resources whenever possible.

2.3 COLUMBIA RIVER STUDIES

The Columbia River Comprehensive Impact Assessment (CRCIA), established in Tri-Party Agreement Milestone M-13-80, will evaluate the current human and ecological risks to the Columbia River attributable to past and present activities on the Hanford Site. The CRCIA is being conducted by Pacific Northwest Laboratory (PNL). Human risk from exposure to radioactive and hazardous materials will be addressed for a range of river use options. Ecological risk will be evaluated relative to the health of the current river ecosystem (Eslinger et al. 1994).

2.4 RISK ASSESSMENT

A QRA was performed for the 100-BC-5 Operable Unit. In addition, the QRA was reviewed and expanded to facilitate evaluation of a final operable unit action at 100-BC-5. The following sections describe the risk assessment activities and results. Appendix A presents an analysis of all rounds of 100-BC-5 LFI data and Appendix B is a report of the supplemental risk assessment conducted for the operable unit.

2.4.1 Qualitative Risk Assessment

The purpose of the QRA at the 100-BC-5 Operable Unit was to focus on a limited set of human and environmental exposure scenarios to provide sufficient information to support defensible decisions on the necessity of IRM.

2.4.1.1 Data Used in QRA. The QRA used the first three rounds of LFI groundwater sampling data. The data were evaluated for consistency and compliance with EPA guidance (EPA 1989). Data from all wells were used to identify a maximum concentration. This maximum concentration was then used in the calculation of human health risk. For the ecological evaluation, maximum concentration data from near-river wells only were used. This data represented a conservative estimate of concentrations available for biological exposure at the groundwater/river interface.

2.4.1.2 Exposure Scenarios. Frequent- and occasional-use exposure scenarios were evaluated in the human health QRA to provide bounding estimates of risk consistent with the residential and recreational exposure scenarios presented in the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1994c). Human exposure was limited to ingestion of contaminated groundwater, inhalation of volatile contaminants during water use, and external exposure to radionuclides.

The results of the human health risk estimates for carcinogens are grouped into the following categories based on lifetime incremental cancer risk (ICR):

- high $>1 \times 10^{-2}$
- medium 1×10^{-4} to 1×10^{-2}
- low 1×10^{-6} to 1×10^{-4}
- very low $<1 \times 10^{-6}$.

Human health risk associated with the occasional-use scenario of medium or high ICR or a hazard index (HI) >1 keeps a waste site on the IRM pathway. Contaminants with hazard quotients (HQ) >1 were identified as contaminants of potential concern (COPC). The results of the ecological risk assessment were evaluated in terms of an ecological hazard quotient (EHQ). Any contaminant with an EHQ >1 was identified as COPC.

The frequent-use scenario assessment identified bis(2-ethylhexyl)phthalate, tritium, carbon-14, strontium-90, and technetium-99 as COPC. The occasional-use scenario resulted in the identification of only one contaminant with an ICR $> 1 \times 10^{-6}$ - strontium-90. However, the ICR for strontium-90 (2×10^{-6}) is in the low range.

Ecological scenarios were evaluated using biological endpoints which live in or near the Columbia River. The ecological risk assessment identified potential risks from aluminum and chromium based on exceedances of Ambient Water Quality Criteria. These exceedances were based on the maximum concentrations detected in the near river wells. No allowance was made for environmental attenuation. These constituents were not identified in the river; the concentrations are significantly reduced by the mixing and dilution action of the river.

2.4.2 Supplemental Risk Assessment

In addition to the QRA and based on agreement of the parties to the Tri-Party Agreement (see Appendix B), some additional risk assessment efforts were performed in support of this FFS. This supplemental risk assessment reviewed data from all rounds of LFI groundwater sampling and included an additional exposure pathway through fish ingestion. Because volatile contaminants were not identified as COPC in the operable unit, the inhalation pathway was not assessed. Likewise, external exposure to beta emitters (such as strontium-90) is generally not a health risk; therefore, this pathway was excluded from the supplemental risk assessment.

2.4.2.1 Data Used in Risk Assessment. This supplemental risk assessment reviewed all five available rounds of data for consistency (see Appendix A); however, only the last two rounds (spring and fall 1993) were used in the risk calculation. The last two rounds represent the most equilibrated data (i.e., completion of new wells has in some instanced artificially elevated metals concentrations; these concentrations generally equilibrate within a few rounds of sampling). Data from the near-river wells were used in the supplemental risk assessment because groundwater concentrations in these wells represent conservative estimates of the concentrations in spring water that could potentially be ingested. Appendix A of this FFS report describes the data evaluation used in the supplemental risk assessment.

2.4.2.2 Exposure Scenarios. The scenarios and pathways for this risk assessment were discussed and selected by the 100 Area Tri-Party unit managers. The occasional-use (i.e., recreational) exposure scenario, as described in the QRA, was used as the basis for the supplemental risk assessment with an additional pathway through fish ingestion. The purpose of the exposure assessment was to estimate the magnitude, frequency, duration, and route of exposure to the COPC that human receptors may experience. This exposure information was then integrated with appropriate toxicity information to provide an assessment of the nature and extent of any health threats from the COPC. The primary components of an exposure assessment are identification of potential human receptor populations and exposure pathways, exposure point concentration, and the quantification of contaminant intakes. The results of the supplemental risk assessment are presented in Tables 2-1 and 2-2. The results of the supplemental risk assessment were the same as the original QRA in that only strontium-90 had an ICR $> 1 \times 10^{-6}$; again, this ICR is within the acceptable low range.

2.4.2.3 Ecological Risk Assessment. No additional risk assessment beyond the QRA was performed on ecological receptors.

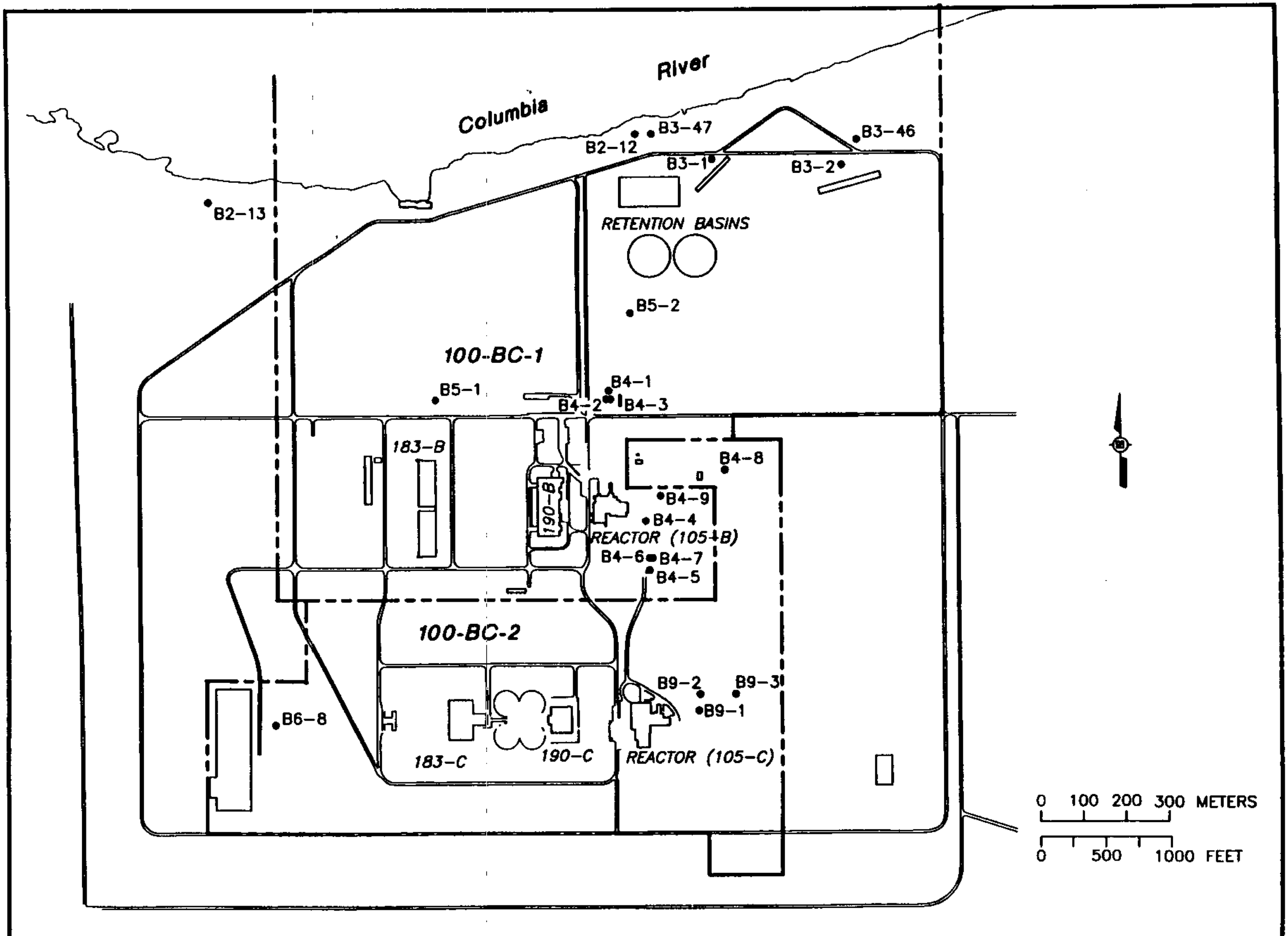


Figure 2-1 Well Location Map

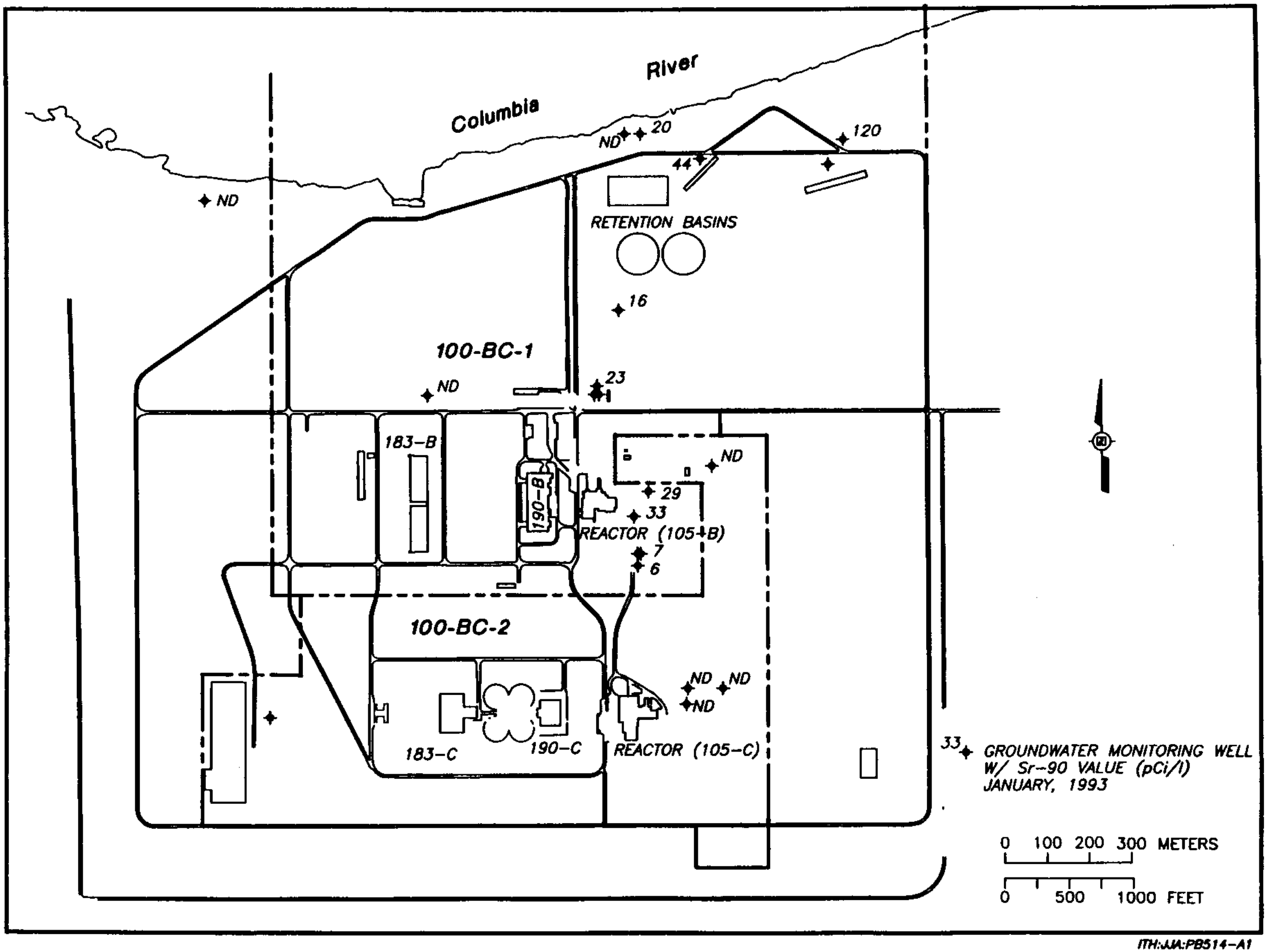


Figure 2-2 Strontium-90 Concentrations

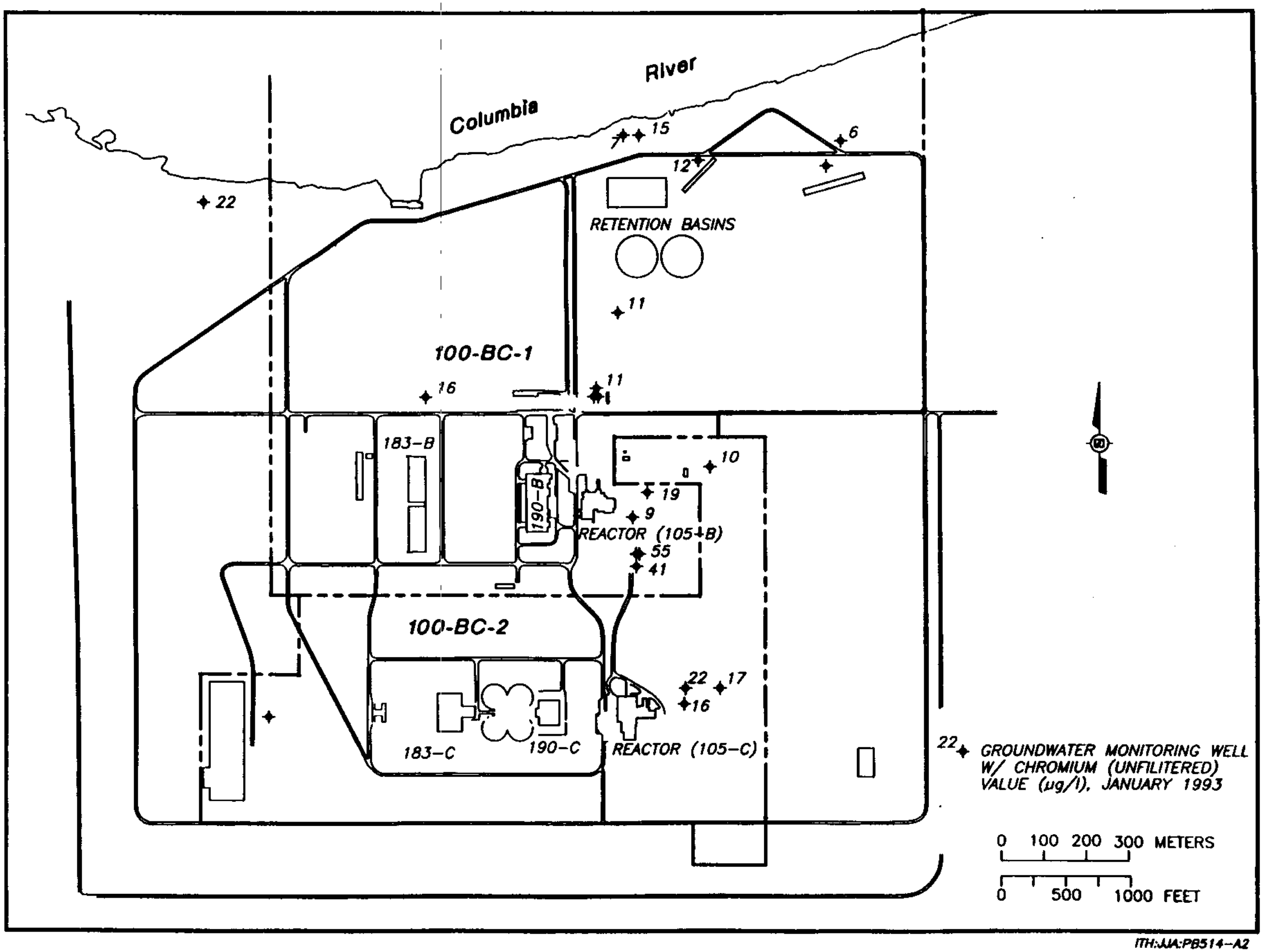


Figure 2-3 Chromium Concentrations

Figure 2-4 Cultural Survey Areas

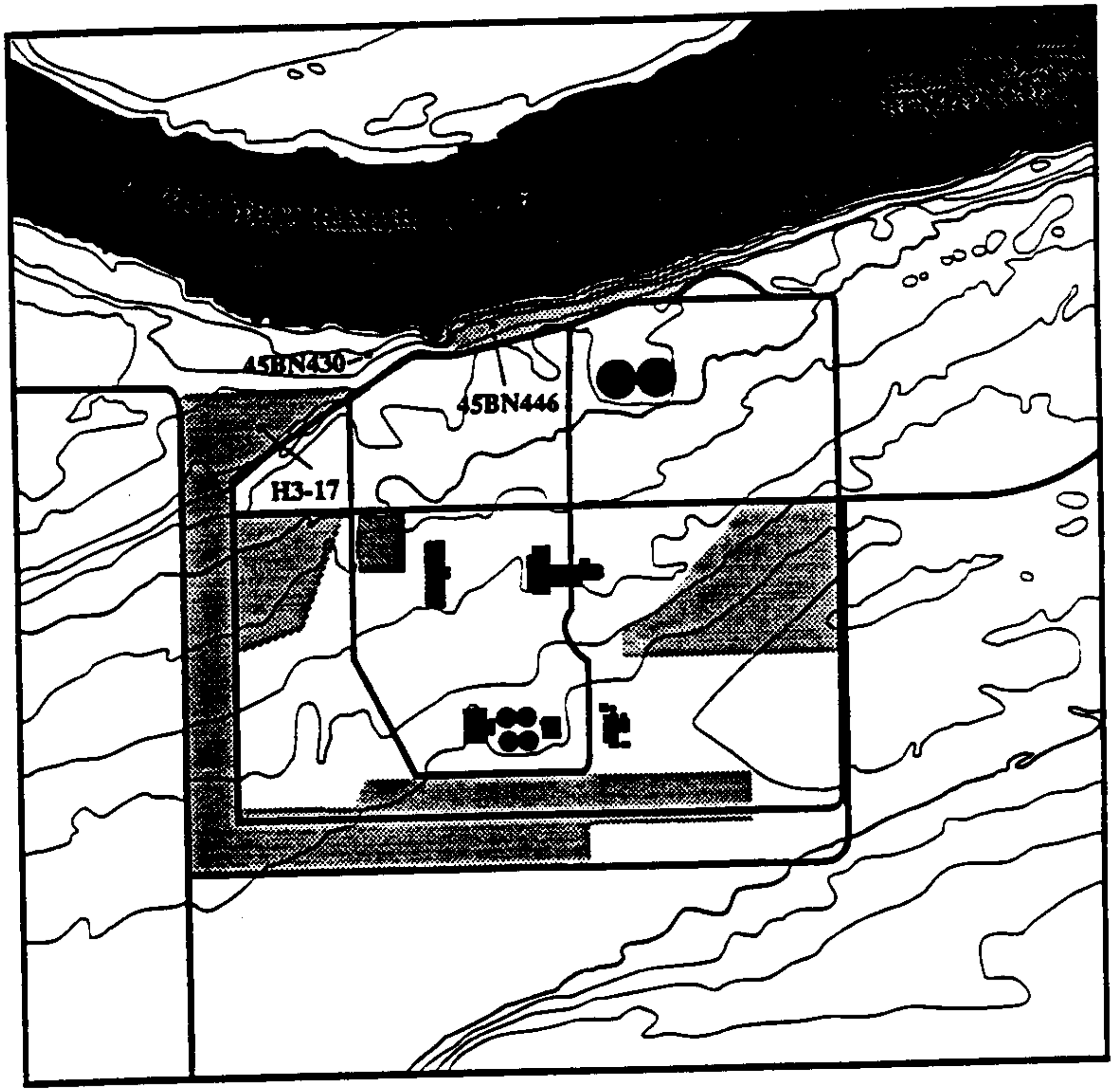


Table 2-1 Summary of Maximum Concentrations for Contaminants of Potential Concern

Analyte	Maximum Groundwater Concentration (All Wells)	Maximum Groundwater Concentration (Near River Wells)	Maximum Spring Concentration	Maximum River Concentration
Strontium-90 (pCi/L)	130	130	6.3	0.6
Aluminum (mg/L)	0.291	0.327	0.268	0.0382
Chromium (mg/L)	0.0268	0.036	0.0541	ND

Table 2-2 Summary of Human Health Risks Data from Supplemental Risk Assessment[1] for the 100-BC-5 Operable Unit

Carcinogenic Parameters		
Parameter	Intake mg/kg-d	ICR
RADIONUCLIDES		
Strontium-90*	5.3E+04	2E-06
Technetium-99	4.6E+04	6E-08
Tritium	5.1E+06	3E-07
ORGANIC COMPOUNDS		
Bis(2-ethylhexyl)Phthalate	2.8E-06	4E-08
Trichloroethene	2.3E-07	3E-09
TOTAL ICR		2E-06

* indicates criterion exceeded
ICR: incremental cancer risk

Noncarcinogenic Parameters		
Parameter	Intake mg/kg-d	HQ
INORGANIC CONSTITUENTS		
Chromium	0.000031	0.006
WET CHEMISTRY AND ANIONS		
Nitrate as N	0.0078	0.005
ORGANIC COMPOUNDS		
Bis(2-ethylhexyl)phthalate	0.000015	0.0007
Trichloroethene	0.0000012	0.0002
TOTAL HI		0.01

HQ: hazard quotient
HI: hazard index

[1] Supplemental risk assessment was based on an occasional-use scenario and analytical data only from the near-river wells from the last two sampling rounds.

Table 2-3 Columbia River Fish Concentrations, Intakes, and Risk Summary

Fish	Source Area	Strontium-90 Concentration pCi/g	Intake pCi	ICR
Whitefish-carcass	100 N	3.2E-02	9.5E+03	3E-07
Carp-carcass	100 N	1.1E-02	3.4E+03	1E-07
Bass-carcass	100 F	3.0E-02	8.8E+03	3E-07

ICR: incremental cancer risk

3.0 REMEDIAL ACTION OBJECTIVES

The RAO are medium-specific or operable unit-specific objectives for protecting human health and the environment. The RAO are based on the land-use, COC, ARAR, exposure pathways, and specify remediation goals so that an appropriate range of remedial options can be developed for analysis. This section presents the steps taken in refining the initial RAO (defined in 100 Area FS [DOE-RL 1994a]) based on a more thorough evaluation of the 100 Area groundwater operable unit data from the LFI reports.

The RAO refinement process begins with the refinement of COPC for the groundwater operable unit. This information is used to ensure that remedial alternatives being considered in this FFS can adequately address the types of contaminants and to facilitate the refinement of ARAR. The RAO also provide the basis for developing the GRA that will satisfy the objectives of protecting human health and the environment. The RAO are defined as specifically as possible without limiting the range of GRA that can be applied.

The RAO for protecting human receptors express both a contaminant level and an exposure route. Remedial action objectives for protecting the environment are expressed in terms of the medium of interest and target clean-up levels, because the intent of the remedial action is to preserve or restore the medium of interest.

Remedial action objectives are based on CERCLA guidance (EPA 1988). Assumptions used to develop RAO for the 100-HR-3 Operable Unit include:

- The main objectives are protection of the river and abatement of migration of contaminated groundwater plumes outside the operable unit.
- The recreational exposure scenario is assumed.
- The IRM will continue to the year 2008, at which time the final action for the operable unit will be implemented, or until cleanup goals are met. (This assumption is for costing purposes and does not represent the final cleanup period.)
- Based on the QRA for the occasional-use scenario, all identified COPC were within acceptable human health risk ranges (i.e., ICR of 1×10^{-4} to 1×10^{-6} or an HQ < 1). Therefore, the potential risk from the operable unit is to the environment.

The RAO for environmental protection are:

- control groundwater movement to prevent release of COC from groundwater to surface water that would result in concentrations in the river in excess of Ambient Water Quality Criteria

- prevent destruction of critical habitat; minimize destruction of noncritical habitat; prevent adverse impacts to threatened or endangered species
- prevent erosion of soil during remediation that would contribute to surface water concentrations greater than the Ambient Water Quality Criteria for the COC in surface water.

Discussion supporting the RAO is given in the subsections below.

3.1 LAND-USE

Although the QRA uses frequent- and occasional-use scenarios (corresponding to residential and recreational uses respectively), there are no residential or recreational land-uses in the 100 Area at this time. The Hanford Future Site Uses Working Group (HFSUWG 1992) recommended the 100 Area be considered for the following four potential future land-uses:

- Native American uses
- limited recreation, recreation-related commercial uses and wildlife
- B Reactor as a museum/visitor center
- wildlife and recreation.

None of the group's recommendations included potential future residential use by definition; however, the scenarios include a range of restricted and unrestricted uses. The DOE currently limits the access to the 100 Area; this access restriction is assumed to continue during the IRM period. Therefore, for purposes of the FFS and given the relative timeframe of the IRM, the recreational scenario will be used to determine remedial action goals for the IRM. As defined in the past-practice strategy, the 100 Area will be reevaluated, including a comprehensive baseline risk assessment, in the future for removal from the NPL. Land-use will be reevaluated at that time.

3.2 CONTAMINANTS OF CONCERN

This section refers to two groups of contaminants, COPC and COC. The first group, COPC, was initially identified in the LFI (DOE-RL 1993b) as contaminants with the potential of having an adverse impact on human health or the environment. The second group is the COC which are refined from the list of COPC. In the context of the FFS, COC are those constituents that must be addressed by remedial actions. The CERCLA requires that actions selected to remediate hazardous waste sites be protective of human health and the environment. In order to support this requirement, COPC identified in the LFI and the supplemental risk assessment are refined to COC for the FFS.

The COPC identified in the LFI were bis(2-ethylhexyl)phthalate, tritium, carbon-14, strontium-90, and technetium-99 based on the first three rounds of LFI data. Subsequent analysis performed in the supplemental risk assessment considered all five rounds of data and determined that the last two rounds were most representative because high concentrations associated with well completion had equilibrated to more realistic values (see Appendices A and B). The supplemental risk assessment identified strontium-90 as COPC. Based on the QRA and the supplemental risk assessment, no human health COC for the 100-BC-5 Operable Unit were identified. Strontium-90 concentrations resulted in a ICR of <1E-4; this represents the largest risk associated with the operable unit. While strontium-90 is not a COC, it was chosen as the contaminant to be considered in the FFS by the unit managers.

For environmental receptors, aluminum and chromium were identified as potential COPC based on an exceedance of ARAR. The values used in the QRA represent maximum concentrations in the near river wells. These concentrations result in a very conservative estimation of risk because the risks associated with the actual river/groundwater interface have not been determined. In addition, a Comprehensive River Study is underway to identify risk associated with the Columbia River. Effects from the 100-BC-5 Operable Unit are being evaluated in this study. Therefore, actions for the operable unit based on ecological risk will be deferred pending the results of ongoing studies.

3.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121 of CERCLA requires that any remedial action selected for a Superfund site be protective of human health and the environment. A component of an action's protectiveness is its ability to comply with ARAR. An ARAR is a promulgated Federal or State environmental cleanup standard, standard of control, substantive environmental protection requirement, criteria, or limitation. It must be either:

- "Applicable," (i.e., specifically addressing the substances, location, or action being considered).
- "Relevant and appropriate," (i.e., addressing a situation sufficiently similar to that encountered at the CERCLA site that its use is well suited to the particular site). A standard or criterion must be both relevant and appropriate to be an ARAR.

There are three categories of ARAR:

- <u>chemical-specific ARAR</u> - numerical values or methodologies used to determine acceptable concentrations of a contaminant
- <u>location-specific ARAR</u> - requirements that dictate or restrict actions at or surrounding the CERCLA site because of sensitive or unique conditions
- <u>action-specific ARAR</u> - technology or activity-based requirements or limitations on actions taken with respect to hazardous waste.

In addition to ARAR, to-be-considered (TBC) guidance consists of nonpromulgated criteria, advisories, guidelines, or proposed regulations. Since TBC guidance is not legally binding, it does not have the status of ARAR; however, TBC are identified and considered if ARAR do not exist for the substances or situations of concern or the ARAR alone would not be sufficiently protective.

The ARAR and TBC used in the analysis of alternatives for the groundwater operable unit FFS are identified in Appendix A. Table 3-1 lists the chemical-specific ARAR and TBC for the COPC for the operable unit. The current MCL for strontium-90 is 8 pCi/L; the proposed MCL is 42 pCi/L. These levels are, however, based on a residential exposure scenario.

The implementation and operation of the remedial alternatives may result in the generation of low-level or mixed waste. The proposed disposal for these wastes would be to the ERDF (if unavailable to meet the required schedule, then existing facilities such as W-025, would be used until the ERDF is available). The ARAR and TBC for the ERDF are not included in the ARAR tables for the FFS. These are addressed in the *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility* (DOE-RL 1994d). Waste acceptance criteria have not yet been developed for ERDF.

3.4 PRELIMINARY REMEDIATION GOALS AND POINTS OF COMPLIANCE

Based on the recreational exposure scenario, the human-health based concentration for strontium-90 at an ICR of 10^{-4} is 6,600 pCi/L (this is based on 2 L/d ingested for 7 d/yr for 30 yr as recommended in HSRAM). The point of compliance for this PRG would be the near-river wells.

Because protection of the river is the goal of the FFS and because the greatest perceived ecological threat is to the eggs and fry of the fish, the point of compliance for ecological PRG should be at the groundwater/river interface. However, monitoring of this interface is difficult. Therefore, the proposed point of compliance is the near-river wells as defined in the QRA. The PRG for this compliance point would be 50 μg/L measured in two consecutive sampling rounds as established in the Tri-Party Agreement Change Control Form M-15-93-02 (Ecology et al. 1994). Chromium concentrations below the chronic Ambient Water Quality Criterion of 11 μg/L as measured in the substrate are considered alternate PRG. These PRG represent screening criteria for the FFS. Final remediation goals will be set in the ROD.

Table 3-1 Chemical Specific ARAR and TBC

Constituent	Safe Drinking Water Act				RCRA Subpart F (e)	MTCA (groundwater/ surface water) (f)	EPA Water Quality Criteria (chronic/acute) (g)	Washington Water Quality Standards (chronic/acute) (h)
	Primary MCL (a)	MCLG (b)	Secondary MCL (c)	Proposed MCL (d)				
Aluminum			50 to 200				146.7/1984	
Chromium	100	100	--	--	50	80/810	11/16	11/16
Strontium-90	8			42				

NOTE: All units for radionuclides in pCi/L; all other units in ug/L.

(a) 40 CFR 141.16 (radionuclides), 40 CFR 141.61 (organics), 40 CFR 141.62 (inorganics), as amended at 56 FR 31838 July 17, 1992
(b) 40 CFR 141.50 and 51 as amended at 56 FR 31838 July 17, 1992
(c) 40 CFR 143.3 as amended at 56 FR 3597 January 30, 1991 - TBC under federal regulations, possible ARAR under MTCA
(d) 56 FR 33120 July 18, 1991 - Proposed rules - TBC
(e) 40 CFR 264.94
(f) WAC 173-340-720, Model Toxics Control Act, Groundwater Cleanup Standards, Method B and WAC 173-340-730 Surface Water Cleanup Standards, Method B
(g) EPA's "Quality Criteria for Water 1986" and EPA's "Update #2 to Quality Criteria for Water 1986" - TBCs for surface waters only
(h) WAC 173-201A-040, Toxic Substances - applies to surface waters only

4.0 ALTERNATIVES DEVELOPMENT

The alternatives developed in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a) provide a range of remedial actions applicable to the general site characteristics and contaminants within the 100 Area. These alternatives are intended to be generally applicable anywhere in the 100 Area. In the FFS, the alternatives are further defined and modified based on additional information from operable unit LFI, 100 Area aggregate studies, and treatability testing. This section describes the groundwater alternatives presented in Appendix D relative to circumstances at the 100-BC-5 Operable Unit. Sections 4.1 through 4.6 describe the application of groundwater alternatives to the 100-BC-5 Operable Unit. Section 4.7 describes uncertainty issues associated with the application of each groundwater alternative.

The DOE's Environmental Management (EM) Office of Technology Development (OTD) (EM-50) is managing an aggressive national program for applied research, development, demonstration, testing, and evaluation. The objective of this program is to develop technologies to cleanup the DOE nuclear production and manufacturing sites and to manage DOE generated wastes more cost-effectively than current environmental cleanup technologies. The program is addressing several major problem areas including groundwater and soil cleanup and waste retrieval and processing. There is a suite of mutually complimentary technologies for environmental restoration in differing stages of development and demonstration that will be ready for implementation in the near future.

4.1 ALTERNATIVE GW-1: NO ACTION

Alternative GW-1, the no action alternative, is required by the National Contingency Plan (NCP) to serve as a baseline for evaluation of other alternatives. The no action alternative may be selected for sites where contamination does not exceed the level of unacceptable risk, where site contamination is in compliance with ARAR, where short-term risks associated with the remedial action exceed the risk of no action, or where the cost of remediation is excessive compared to the benefit gained in risk reduction.

The no action alternative for the groundwater operable units consists of continued groundwater monitoring which is currently ongoing at the site. The contamination is allowed to dissipate through natural attenuation processes. For radionuclides, this is mainly natural radioactive decay. The effectiveness of the natural attenuation process is related to the half-life of the radionuclide and the affinity of the radionuclide to adsorb to the Hanford Site soils. For other contaminants, such as chromium, the major attenuation factor is advection/dispersion, which depends on natural groundwater flow and the river flushing action to reduce concentrations.

Application of the no action alternative is independent of any site-specific considerations, as this alternative requires no restrictions, controls, or active remedial measures. Therefore, the baseline description for this alternative as presented in Appendix D is directly applicable to the 100-BC-5 Operable Unit without modification.

4.2 ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/CONTINUED CURRENT ACTIONS

Alternative GW-2 has been developed as an institutional controls GRA. Alternative GW-2 was initially developed in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a) to prevent access to contaminated groundwater plumes beneath the 100 Area. The following process options are specified for the alternative:

- access restrictions:
  - deed restrictions
  - water rights restrictions
- monitoring:
  - groundwater monitoring
- continued current actions:
  - pilot-scale treatability test in 100-HR-3 Operable Unit
  - groundwater/river interaction studies
  - chromium speciation studies
  - Columbia River Comprehensive Impact Evaluation study
  - source remediation activities.

4.2.1 Access Restrictions

The access restrictions included in this alternative are unique to groundwater media. Government control of the Hanford Site, and therefore the operable unit, is anticipated through the IRM period. Sitewide access restriction measures already existing at the Hanford Site, such as security fences and guarded entrances, will ensure 100-HR-3 groundwater is not accessible to the general public. Deed restrictions and water rights are not required during the period of government control. The institutional controls alternative therefore does not require implementation, but only continued maintenance and enforcement.

4.2.2 Monitoring

In addition to restricting groundwater use and access to groundwater, the institutional action alternative also includes groundwater and environmental monitoring. Monitoring will be required to determine if and when institutional controls to restrict access to groundwater are no longer necessary.

4.2.3 Continued Current Actions

The continued current actions listed are efforts currently underway to complete the conceptual model of the groundwater operable units and to generate more certain technology performance data. These efforts support the selection of the most appropriate remedial action for the 100 Area groundwater operable units. The treatability test will provide data on technology performance and optimization, on waste generation, and possibly on aquifer response. The river/groundwater interaction studies will help describe the mixing zone to better predict the hydrologic actions affecting concentrations. The speciation studies will better quantify the amount of chromium (VI) to provide a more realistic conceptual model of contaminant movement in the aquifer and interaction with the sediments. The river impact assessment will provide risk assessment data specific to and the receptors in the river. All the information will be assessed to determine the best solution for the remediation of the operable unit. Remediation of the sources will eliminate continuing source terms to groundwater contamination. This remediation may result in significantly lower groundwater concentrations. When the results of the current actions are available, the conceptual model may be complete enough to identify a final action for the operable unit.

4.3 ALTERNATIVE GW-3: CONTAINMENT

The containment alternative consists of remedial actions designed to ensure containment of contaminated groundwater plumes. The general description of this alternative (Section 1.3 of Appendix D) presents several subsurface barrier (cutoff wall) technologies that are potentially applicable in the 100 Area. The most appropriate cutoff wall technology for application at the 100-BC-5 Operable Unit is determined on the basis of site-specific implementation requirements. These requirements include consideration of the site geologic formation and wall depth requirements. For the purposes of the FFS, groundwater modeling results are used to establish the optimum configuration of the cutoff wall and hydraulic control wells for the evaluation of alternatives (additional optimization would be required for remedial system design).

4.3.1 Cutoff Wall Selection

Selection of the cutoff wall technology considered most appropriate for the 100-BC-5 Operable Unit is based primarily on the following requirements:

- the technology must be implementable to a depth sufficient to key-in the uppermost confining layer beneath the unconfined aquifer
- the technology must be implementable in the Hanford formation where granite and basalt boulders exist in a silty sand matrix
- application of the technology must minimize exposure to contaminated soil and groundwater during implementation
- the technology must be implementable within the spatial constraints imposed by proximity of the Columbia River and the past-practice disposal facilities (e.g., retention basins, cribs, and trenches).

Sheet pile technology is not considered implementable in the Hanford formation where boulders can deflect or damage the metal sheets during installation. In addition, the 45 m (150 ft) wall depth required at the 100-BC-5 Operable Unit is beyond the capability of conventional sheet pile technology. Based on these implementation concerns, sheet pile technology is not recommended for application at the 100-BC-5 Operable Unit.

Conventional slurry wall technology is considered difficult to implement at the 45 m (150 ft) depth required for the 100-BC-5 Operable Unit. However, modified slurry wall construction techniques, such as the Bauer-Slurry-Trench-Cutter developed by Bauer of America, can be used to construct diaphragm cutoff walls to depths well below the capabilities of conventional excavation techniques. The primary drawback to slurry wall construction at the 100-BC-5 Operable Unit is the unavoidable contact with contaminated groundwater and soil within the unconfined aquifer. Downgradient placement of a slurry wall to intercept migration of the strontium-90 plume into the river would require excavation into the contaminated portion of the aquifer. This would result in significant contamination control requirements as well as handling and disposal of excavated spoils and excess slurry. Slurry wall technology is therefore not considered for use at the 100-BC-5 Operable Unit due to unavoidable contact with contamination resulting in waste generation (contaminated slurry and excavated spoils).

Deep soil mixing technology is considered implementable to the 45 m (150 ft) depth required at the 100-BC-5 Operable Unit. Deep soil mixing techniques greatly reduce or eliminate exposure to contaminated materials during installation. However, the presence of boulders within the Hanford formation present construction difficulties. Deep soil mixing is therefore judged to be difficult to implement at the 100-BC-5 Operable Unit.

Each individual cutoff wall technology has implementability limitations for one or more reasons. A combination of cutoff wall technologies is therefore proposed to eliminate the limitations associated with the individual technologies. Deep soil mixing is considered the most appropriate cutoff wall technology due to minimal contact and exposure to contamination. However, utilization of this technology would require the boulders in the Hanford formation to be removed.

A pre-excavation to remove boulders within the 15 m (50 ft) thick vadose zone (DOE-RL 1993b) could facilitate the use of deep soil mixing. Conventional excavation in the vadose zone may not be applicable since a 15 m (50 ft) deep trench with 1.5 to 1 side slopes would result in an approximate 45 m (150 ft) width at the surface. Based on the proximity of the river and past-practice disposal units (retention basins, cribs, trenches), such an excavation would not be appropriate. The pre-excavation could be performed similar to the construction of a slurry wall in which a vertical wall trench is excavated. The resulting trench could then be backfilled with the soil originally removed (without boulders).

The cutoff wall design proposed for the 100-BC-5 Operable Unit, is deep soil mixing after pre-excavation to remove boulders in the Hanford formation. The pre-excavation is to be performed by slurry trench excavation to minimize the extent of lateral disturbance on the surface. Deep soil mixing can then be performed within the trench constructed during the pre-excavation. The pre-excavation trench can be simply backfilled with soil. This cutoff wall concept fulfills the design considerations established for implementation at the 100-BC-5 Operable Unit, such as depth to a confining layer, minimized exposure to contamination, and construction limitations due to boulders and spatial constraints.

4.3.2 Containment System Configuration

Within the 100-BC-5 Operable Unit, groundwater in the unconfined aquifer flows towards the Columbia River (DOE-RL 1993b). Therefore, down gradient placement of the cutoff wall as close as reasonably possible to the river is proposed. Based on the near river topography in the 100 B/C Area, the location proposed for placement of the cutoff wall is approximately 30 m (100 ft) from the river. The distance between the river and the cutoff wall enables sufficient space for construction without interference from the steep bank that drops approximately 9 m (30 ft) to the river (DOE-RL 1993b).

Contamination is assumed to be limited to the unconfined aquifer, based on characterization activities performed during the LFI which indicate that no contamination is present in the uppermost confined aquifer (DOE-RL 1993b). The unconfined aquifer is bounded on the bottom by paleosols and overbank deposits approximately 34 m (110 ft) thick (DOE-RL 1993b). This underlying layer acts as an aquitard which separates the unconfined aquifer from the underlying confined to semi-confined aquifers and prevents vertical contaminant migration. The cutoff wall can be keyed into this layer to prevent groundwater from moving under the wall.

The vadose zone is comprised of Hanford formation soils (boulder gravel) approximately 15 m (50 ft) thick near the Columbia River (DOE-RL 1993b). The unconfined aquifer consists of Ringold Formation soils (coarse-grained fluvial sediments) which are approximately 30 m (100 ft) thick (DOE-RL 1993b). The required depth of the wall will therefore be approximately 45 m (150 ft), including an additional 1 m (3 ft) for key-in to the aquitard.

The 100 B/C Area cutoff wall would be constructed along the Columbia River and will span the length of the strontium-90 plume identified in the LFI (DOE-RL 1993b). This wall will also contain the other constituent plumes identified at the 100 B/C Area that coexists within the strontium-90 plume (tritium and technetium-99). Groundwater modeling results (see Section 5.0) indicate the length of the wall required for the 100-BC-5 Operable Unit should be approximately 450 m (1,500 ft).

The description of this alternative presented in Section 3.3 of the methodology document specifies upgradient extraction wells to control the hydraulic head behind the barrier, and injection wells placed downgradient to maintain the hydrologic conditions in the aquifer near the barrier. The hydraulic gradient in the 100-BC-5 Operable Unit may be sufficiently small to eliminate the need for the extraction/injection well system proposed. At high river stage the groundwater gradient is estimated to be approximately $8x10^{-4}$ across the entire site (DOE-RL 1993b). At low river stage the gradient is still flat across the reactor areas but becomes steep ($3x10^{-2}$) adjacent to the river (DOE-RL 1993b). Results of groundwater modeling indicate one pumping well located at each end of the cutoff wall, enhances plume containment by preventing contaminated groundwater from escaping around the ends of the wall. Since the extracted groundwater will likely contain strontium-90 (and possibly other constituents), injection in the upgradient portion of the contaminant plume is required to prevent contamination spread.

Figure 4-1 presents a cross-section through the near-river wells. Figure 4-2 illustrates the containment system configuration at the 100-BC-5 Operable Unit.

4.3.3 Containment System Implementation

Implementation of the containment system for the 100-BC-5 Operable Unit requires construction of a 450 m (1,500 ft) long by 45 m (150 ft) deep cutoff wall. This wall would be constructed along the Columbia River approximately 30 m (100 ft) from the river bank (see Figure 4-2). Construction of this barrier would be performed in two phases. The first phase consists of a pre-excavation along the length of the cutoff wall to remove boulders located within the Hanford formation. The second phase involves deep soil mixing to construct the cutoff or diaphragm wall by overlapping columns of soil/bentonite and or soil/cement mixtures. Figure 4-3 depicts the two phased approach to implementation of the cutoff wall.

In the first phase, slurry trench excavation is used to remove boulders in the Hanford formation along the 450 m (1,500 ft) length of the cutoff wall. The slurry excavation technique enables construction of a trench with near vertical side slopes. The physical constraints imposed by the proximity of the river and past-practice disposal facilities (retention basins, cribs, and trenches) prevent the use of conventional excavation techniques which typically involve 1.5 to 1 side slopes. During excavation the slurry forms a filter skin or cake on the trench walls. This filter cake allows the slurry to form hydraulic pressure against the trench walls which prevent collapse.

The density of Hanford formation soil is approximately 1.98 g/cm^3 (DOE-RL 1993b) and forms the basis for the slurry density required during the excavation. Since the pre-excavation is maintained in the vadose zone, consideration of hydraulic pressure from groundwater is not required. High density slurries can be obtained using mixtures of barium sulfate (barite specific gravity, G = 4.3 to 4.5) and bentonite clay (specific gravity, G = 2.13 to 2.18) (Bowles 1988). Other materials including silt and fine sand from the excavation may be used to reduce the quantity of commercial admixtures. Losses into the formation are not expected due to the approximate 10^{-4} cm/s vertical hydraulic conductivity reported in the 100-BC-5 Operable Unit LFI (DOE-RL 1993b). Use of a high density slurry should more easily form a uniform filter skin that evenly distributes hydraulic pressure against the trench walls.

The second phase of construction involves the use of deep soil mixing within the trench formed during boulder removal from the Hanford formation. The trench formed during pre-excavation is backfilled with the soil originally removed (without boulders). Consequently, deep soil mixing is performed from the surface through the backfill material and the unconfined aquifer. The total depth from ground surface required to key-in the cutoff wall to the paleosols and overbank deposits that underlay the unconfined aquifer is approximately 45 m (150 ft) (see Figure 4-3).

Deep soil mixing utilizes either cement, bentonite, or a combination of cement and bentonite to mix with in-place soil. The technique involves formation of overlapping, cylindrical columns to create a cutoff wall with a specified strength and permeability. Since in-place soil is used in the formation of the containment structure, disposal of contaminated material is not required. The effect of this technique on the hydraulic conditions of the aquifer is negligible and previous water table conditions are re-established in a relatively short time period. Four foot diameter columns are specified for the formation of the cutoff wall to a depth of 100 feet below the trench formed during pre-excavation.

The hydraulic conductivity of the unconfined aquifer near the Columbia River ranges from 5×10^{-3} to 2×10^{-2} cm/s (DOE-RL 1993b). Based on the materials used in the formation of a deep soil mixing cutoff wall, the hydraulic conductivities achievable are considered similar to a conventional slurry wall (approximately 1×10^{-7} to 1×10^{-6} cm/sec for soil-bentonite and soil-cement, respectively [Spooner et al. 1985]).

4.3.4 Containment System Modeling Results

Groundwater modeling results indicate the containment system described above can significantly reduce the mass of strontium-90 entering the Columbia River. In comparison to the baseline, or no action, an 87% reduction in the mass of strontium-90 entering the river is achieved during the 15 and 25 year simulation periods. Although some leakage past the containment system can be expected, the flow rate of contaminated groundwater into the river is shown to be significantly reduced. Leakage of contaminants to the river would be unavoidable due to the contaminated matrix left between the river and the cutoff wall. Because contaminants are adsorbed to the soil matrix, the concentrations of the strontium-90 does not significantly reduce over time except for reduction through natural decay. However, the wall affects the overall groundwater gradient by decreasing the flow of the more highly contaminated groundwater and increasing the flow of the less contaminated groundwater associated with the outer edges of the plume. This results in a net flow of groundwater in the system equal to the no action alternative; however, the flow of contaminants is greatly reduced by the wall.

Modeling results for the containment alternative show contaminant concentrations in 100-BC-5 groundwater will diminish over time according to the decay of strontium-90. This result is anticipated since the contaminant plume is isolated from potential mixing or dilution with the Columbia River. The duration of isolation required would be dependent on the concentration considered acceptable for release into the river. Assuming a 30 year half-life for strontium-90 and a release criteria identical to the SDWA MCL, the duration of containment required will be similar to the discussion presented previously for the institutional controls alternative (see Section 4.1.2.1). The maximum concentration of strontium-90 reported in the 100-BC-5 Operable Unit LFI (DOE-RL 1993b) (130 pCi/L), would decay to the 8 pCi/L SDWA MCL after approximately 120 years or to the proposed 42 pCi/L SDWA MCL after approximately 49 years.

4.4 ALTERNATIVE GW-4: IN SITU TREATMENT

The general description of Alternative GW-4 (see Section 1.4 of Appendix D) includes remedial technologies for in situ treatment of nitrate and volatile organic compounds in the groundwater beneath the 100 Area. This alternative is not considered applicable to the 100-BC-5 Operable Unit, because the in situ treatment of strontium-90 is not feasible. On this basis, no further discussion of the in situ treatment alternative is necessary.

4.5 ALTERNATIVE GW-5: REMOVAL/TREATMENT/DISPOSAL

The general description of Alternative GW-5 presented in Section 1.5 of Appendix D specifies remedial technologies for removal, treatment, and disposal of contaminated groundwater beneath the 100 Area. The system is specified for containment of the contaminant plume and not for mass reduction. Modifications to the baseline description are required based on the COC identified for the operable unit. Because the removal, disposal, and monitoring aspects of this alternative are independent of the site-specific conditions at each 100 Area groundwater operable unit, modifications to the baseline alternative are specific to the proposed treatment system.

4.5.1 Treatment System Modifications

The baseline treatment system specified for Alternative GW-5 is modified to address the COC identified in 100-BC-5 groundwater. Strontium-90 is a contaminant of interest in 100-BC-5 groundwater; therefore, several treatment processes specified in the baseline alternative are either no longer necessary or require modification. The baseline chemical oxidation, biodenitrification, and chemical reduction systems are not required for treatment of 100-BC-5 groundwater because organics and nitrates are not COC and because treatability testing have shown ion exchange to be sufficient for treating hexavalent chromium. Chemical precipitation and ion exchange, either alone or in combination represent potential treatment options for removing strontium-90 from 100-BC-5 groundwater. Additional information on the precipitation process is included. However, sufficient information is not available to select the best system. For purposes of the FFS, the ion exchange system will be assumed for costing purposes. Additional treatability testing would provide additional information for determining the optimum system.

Modifications to the baseline chemical precipitation process involve refinement for removal of strontium-90. The EQ3/6 computer code was used to simulate chemical precipitation of strontium-90 based on the groundwater chemistry data reported in the 100-BC-5 Operable Unit LFI (DOE-RL 1993b). The EQ3/6 computer code is an industry-standard chemical equilibrium model developed at the Lawrence Livermore National Laboratory. The model performs solubility, speciation, and reaction-path calculations. Computer simulations involving lime (CaO) treatment were conducted to assess the effectiveness of precipitation of strontium-90 in 100-BC-5 groundwater. In theory, the addition of lime (CaO) to the groundwater will raise the pH and the calcium concentration, which will cause precipitation of calcium carbonate. Dissolved strontium-90 will also partition into the carbonate precipitate either as a discrete strontianite ($SrCO_3$) phase or as a small fraction of strontianite in a calcite ($(CaSr)CO_3$) phase.

Treatment of 100-BC-5 groundwater by the addition of lime was simulated with the EQ3/6 model. The model predicted the concentration of strontium-90 in 100-BC-5 groundwater could be reduced by over 99%. This result was shown to be independent of the two initial strontium-90 concentrations used, based on an estimated average concentration of 17 pCi/L and a peak concentration of 130 pCi/L. The solubility of strontium in bicarbonate-bearing groundwater is a function of pH. The minimum solubility of strontium-90 which corresponds to the maximum formation of precipitates occurs at a pH between 10.3 and 10.4. Figures 4-4 and 4-5 illustrate the relationship between pH, total dissolved strontium, and dissolved strontium-90 after lime treatment. Figure 4-6 shows the predicted relationship between the lime addition and strontium-90 removal.

Effluent from the precipitation process may require pH adjustment due to the high pH needed to precipitate strontium-90 in the groundwater. The addition of an acidification agent, such as sulfuric acid, is considered a simple approach to reducing the pH of the precipitation process effluent. The required adjustment will be dependent on the disposition of the effluent. Subsequent treatment, such as ion exchange for final polishing, may be required and may need a specific influent pH to maximize strontium-90 removal, whereas direct disposal may require a pH value equivalent to the aquifer (i.e., between 7.5 and 8.3 [DOE-RL 1993b]).

The ion exchange system is also modified for removal of strontium-90. Since strontium-90 exists as a divalent cation in groundwater, anion exchange is not required. Three cation exchange columns arranged in a parallel configuration are proposed. During normal operations two columns are active while the third is kept off-line for maintenance back-up. Naturally occurring zeolites, such as chabazite and clinoptilolite, have been effectively demonstrated for removing strontium-90 from groundwater (Robinson et al. 1993).

Regeneration is no longer included in the ion exchange treatment system design, based on the technical complexity of regeneration and the additional volume of secondary waste generated by regeneration. Once strontium-90 breakthrough is detected, spent exchange material is hydraulically removed from the exchange columns into a dewatering vessel followed by load-out into disposal containers. Fresh exchange media is then pneumatically transferred into the ion exchange vessel. Figure 4-7 illustrates the treatment system concept proposed for Alternative GW-5.

Secondary waste streams generated as a result of groundwater treatment may or may not require treatment prior to disposal depending on the requirements of ERDF. The baseline cement-based solidification system is retained for liquid- and sludge-type secondary waste streams generated to eliminate free liquids and immobilize strontium-90 contamination. The secondary wastes likely to require cement solidification include settling tank sludge and residues from the rotary drum filter. Spent ion exchange media may not require solidification prior to disposal due to the dewatering process prior to packaging for disposal.

4.5.2 Site-Specific Implementation

Application of Alternative GW-5 to the 100-BC-5 Operable Unit was simulated by groundwater modeling to optimize the location and pumping requirements of the extraction well system for the purposes of the FFS (additional optimization would be required for remedial design). Optimization is based on reduction of contaminated groundwater migration into the Columbia River. Other considerations include uptake of river water and aquifer restoration. Modeling results indicate the optimum location of the extraction well system consists of a line of four extraction wells placed 30 m (100 ft) from the river bank and spaced approximately 100 m (330 ft) apart. The combined extraction rate of the system is approximately 400 gpm (100 gpm per well). Figure 4-8 illustrates the proposed groundwater extraction system configuration.

4.5.3 Operational Considerations

In addition to the strontium-90 identified in 100-BC-5 groundwater (strontium-90), low concentrations of other contaminants such as tritium and technetium-99 are also present within the plume (DOE-RL 1993b). Although these contaminants may enter the treatment system, significant dilution is anticipated within the 400 gpm design flow rate. Contingency for high concentrations of tritium is designed into the disposal options. Treated groundwater found to contain excessive concentrations of tritium will be reinjected into the aquifer upgradient of the extraction wells. Otherwise, treated groundwater would be discharged directly into the river.

Based on the capacity of the extraction system, a 400 gpm flow rate will require processing in the treatment system. Treatability studies will be required to define full-scale operating requirements due to the difficulties associated with processing such a high volumetric flow rate. Operational difficulties may include mixing inefficiencies during the precipitation process that can significantly impact the quantity of lime required. Similarly, insufficient residence times in either the clarifier tank or the ion exchange columns can adversely impact the efficiency of these processes.

The chemistry of 100-BC-5 groundwater as well as the chemical speciation of the contaminants in the groundwater will influence the design and operation of the chemical precipitation processes. The EQ3/6 computer code was used to establish the feasibility of lime treatment to remove strontium-90 from 100-BC-5 groundwater. However, treatability tests will be required to establish optimum operating conditions. The addition of flocculants or coagulants may be required to induce settling of the precipitates in the clarifier tank.

Efficiency of the ion exchange process will depend on: resin selectivity for the strontium cation; competing noncontaminant ions; pH of the groundwater; concentration of suspended solids; and speciation of strontium. The precipitation-filtration process should significantly reduce the concentrations of any noncontaminant ions (e.g., calcium and magnesium) present in groundwater that would otherwise compete for adsorption sites on the exchange resins. The rotary drum filtration process should also minimize the concentration of suspended solids. Resin specification will be determined by treatability studies.

However, naturally occurring zeolite, such as chabazite and clinoptilolite, have been effectively demonstrated for removing strontium-90 from the groundwater (Robinson et al. 1993).

4.5.4 Modeling Results

Groundwater modeling results indicate the removal, treatment, and disposal alternatives can effectively control the migration of strontium-90 contaminated groundwater into the Columbia River. In comparison to the baseline (no action), an approximate 92% reduction in the mass of strontium-90 entering the river is achieved during the 15 and 25 year simulation periods. This result indicates the hydraulic effects of the extraction well system significantly reduce the flow rate of groundwater into the Columbia River.

During the 15 and 25 year simulation periods, the groundwater modeling results do not show any additional reduction in the concentration of strontium-90 compared to the no action alternative. The equivalent decrease in strontium-90 concentration shown for the no action alternative and the removal, treatment, and disposal alternatives is equivalent to radioactive decay. The reason pump-and-treat does not have any additional affect on the concentration of strontium-90 is believed to be a result of the high adsorption coefficient of strontium-90 in the aquifer formation. The adsorption coefficient, k_D, for strontium-90 in the Ringold Formation soil ranges from approximately 20 to 200 ml/g (Ames and Serne 1991). Based on the range of adsorption coefficients, the majority of the strontium-90 mass is predicted to be adsorbed onto the formation soil.

The negligible difference between strontium-90 concentrations in the groundwater shown for no action and pump-and-treat can be attributed to the slow process of desorption of strontium-90 from the aquifer formation. As contaminated groundwater is removed by the extraction system, strontium-90 desorbs from the soils. The actual desorption rate of strontium-90 in the unconfined aquifer is unknown; however, this rate will be less than that of adsorption. The continual desorption will essentially maintain the concentration of strontium-90 in the groundwater at the same steady-state value for a long period of time. The significance of this result is that the extraction system acts an effective hydraulic control measure to prevent the flow of contaminated groundwater into the Columbia River, but the alternative may not significantly affect the concentration of strontium-90 in the groundwater. The pump and treat system does result in significant reductions in the flow of contaminated groundwater even though the concentrations remain high. The effect is the same concentration at a greatly reduced volume reaching the river and is quantified by the reduction in the mass of strontium-90 going to the river.

Groundwater modeling results are independent of the treatment system because the model does not account for above ground activities. The disposal aspects of this alternative are also not included in the groundwater modeling results. Effluent from the treatment systems is to be discharged directly into the Columbia River (if tritium concentrations are below the SDWA MCL) or injected into the unconfined aquifer (if tritium concentrations are above the SDWA MCL).

4.6 ALTERNATIVE GW-6: REMOVAL, TREATMENT, DISPOSAL

Alternative GW-6 is similar to Alternative GW-5 in that both alternatives specify remedial technologies for removal, treatment, and disposal of contaminated groundwater beneath the 100 Area. The system is specified for containment of the contaminant plume and not mass reduction. The primary difference between these alternatives is the treatment technologies specified. Therefore, the general description of Alternative GW-6 also requires modification for application to the COC identified in the 100-BC-5 Operable Unit. Since the removal, disposal, and monitoring aspects of this alternative are independent of the site specific conditions at each 100 Area groundwater operable unit, modifications to the baseline alternative are specific to the proposed treatment system.

4.6.1 General Description Deviations

The general treatment system described for Alternative GW-6 (see Section 1.6 of Appendix D) is modified on the basis of the COC identified in 100-BC-5 groundwater. As described for Alternative GW-5, no organic COC are identified in 100-BC-5 groundwater. Therefore, the air stripping/carbon adsorption process for removal of organic contaminants can be eliminated from the baseline treatment system. No other modifications to the baseline treatment system for Alternative GW-6 are required.

The modification described above reduces the baseline treatment system to reverse osmosis followed by evaporation of the reverse osmosis concentrate. Groundwater fed into the treatment system is pretreated by pH adjustment and a crystallization inhibitor to maximize the efficiency of the reverse osmosis process. Cement solidification is retained for treatment of concentrate from the evaporator and other secondary wastes (settling tank sludge). Liquid effluent from the process is disposed as described in the baseline description of this alternative. Figure 4-9 presents a conceptual flow diagram of the modified treatment system proposed for application of Alternative GW-6 to the 100-BC-5 Operable Unit.

4.6.2 Site-Specific Implementation

The site-specific implementation discussion described previously for Alternative GW-5, is the same for Alternative GW-6. The extraction well system configuration consists of four wells with a combined pumping rate of approximately 400 gpm. The four extraction wells would be located approximately 30 m (100 ft) from the river bank and spaced approximately 100 m (330 ft) apart. Figure 4-8 presents the extraction system configuration for the 100-BC-5 Operable Unit.

4.6.3 Operational Considerations

Similar to the discussion present for Alternative GW-5, low concentrations of other contaminants such as tritium and technetium-99 are also present within the strontium-90 plume (DOE-RL 1993b). These other contaminants may enter the treatment system;

however, significant dilution is anticipated within the 400 gpm design flow rate. Treated groundwater found to contain excessive concentrations of tritium will be injected into the aquifer upgradient of the pumping wells; otherwise, treated groundwater would be discharged directly into the river.

Reverse osmosis has been demonstrated for removal of strontium-90 from groundwater and other liquid waste streams (Garrett 1990, Ebra et al. 1987). Rejection efficiencies over 99% were obtained in tests conducted at the Hanford Site (Garrett 1990). Similar test results also indicate reverse osmosis to be effective for strontium-90 removal (Ebra et al. 1987). However, the efficiency of reverse osmosis obtained in these tests was based on initial strontium-90 concentrations significantly higher than the 130 pCi/L peak concentration found in 100-BC-5 groundwater. Treatability studies would therefore be required to demonstrate the effectiveness of reverse osmosis for removal of strontium-90 at the low concentrations found in 100-BC-5 groundwater. Treatability studies would also be required to establish full-scale operating conditions based on the required 400 gpm flow rate.

Evaporation technologies have been used extensively for treatment of radioactive liquid wastes. As discussed in the baseline description of this alternative, the purpose of the evaporation process is to reduce the volume of reverse osmosis concentrate. Contaminated water from the Three Mile Island accident wastewater was treated with a vapor recompression evaporator. The evaporation process also included an auxiliary evaporator, flash vaporizer, and a concentrate dryer. The process effectively concentrated strontium-90, as well as other radionuclides, and resulted in a 56:1 volume reduction (Williams and Strand 1990).

4.6.4 Modeling Results

The groundwater modeling results described previously for Alternative GW-5 (see Section 4.1.5.4) are also applicable to Alternative GW-6.

4.7 UNCERTAINTY ISSUES

Application of the groundwater alternatives at the 100-BC-5 Operable Unit involve some degree of uncertainty as to implementability and effectiveness. Although other considerations such as community and regulatory acceptance of an alternative will also be uncertain, only technical uncertainty is addressed here. The following sections describe the uncertainty associated with each groundwater alternative relative to the 100-BC-5 Operable Unit.

4.7.1 Alternative GW-1

There is no uncertainty associated with implementation of this alternative since no action is required. However, there is uncertainty associated with the effectiveness of the no action alternative based on the concentration of strontium-90 available for human and environmental receptors should no action be implemented. Although the 100-BC-5 Operable Unit LFI (DOE-RL 1993b) indicates low risk to human health and the environment, the assessment is based on near river well concentrations. Mixing at the interface between the river and the groundwater would significantly reduce the concentration of strontium-90 available to human and environmental receptors. The uncertainty could be lessened by modeling the interface between the river and the groundwater to determine the extent of mixing.

4.7.2 Alternative GW-2

Implementation of the institutional controls alternative is relatively straight forward requiring only administrative effort and legal enforcement. The uncertainty associated with this alternative involves effectiveness. Institutional controls will have no affect on the migration of contaminated groundwater into the river. Based on recreational use of the 100 Area, this alternative is essentially equivalent to the no action alternative in the period of governmental control.

4.7.3 Alternative GW-3

The uncertainty associated with the containment alternative is the implementability of the cutoff wall. Removal of boulders from the Hanford formation using slurry-type excavation techniques may be difficult. However, conventional excavation would not be applicable due to spatial constraints imposed by the river and past-practice disposal sites (retention basins, trenches, cribs). The potential for contamination within the vadose zone along the proposed location of the cutoff wall could also impact the ability to remove boulders from displaced Hanford formation soil. Assuming the pre-excavation, boulder removal is successful, deep soil mixing to the 45 m (150 ft) depth required may still be difficult. Excavation and deep soil mixing pilot tests would reduce the uncertainty associated with installation of the cutoff wall.

An additional source of uncertainty associated with the effectiveness of the containment alternative is the permanence of the cutoff wall. Once sufficient time has elapsed to decay strontium-90 to nonhazardous concentrations, the cutoff wall will no longer be required but will likely still exist. Removal of the wall, if required, could be achieved through drilling or excavation.

4.7.4 Alternative GW-4

The in situ treatment alternative is not applicable to the conditions in the 100-BC-5 Operable Unit. Therefore no discussion of uncertainties is presented.

4.7.5 Alternative GW-5

The primary uncertainty associated with this alternative is the effectiveness of pump and treat to remediate the contaminated portion of the unconfined aquifer. Conventional pump and treat methods have been shown to reduce contaminant mass and prevent further migration, however, the ability to reduce contaminant levels to drinking water standards has been limited (PE 1993). This concern is directly applicable to 100-BC-5 groundwater where the high adsorption coefficient associated with strontium-90 indicates an equivalent, if not lower, desorption rate. Treatment of many equivalent plume volumes of contaminated groundwater may be required to remediate the contaminated portion of the unconfined aquifer. As indicated in the groundwater modeling results, pump-and-treat does not reduce the concentration of strontium-90 in the groundwater beyond the rate of decay indicated by the no action alternative. The significance of the high adsorption and low desorption rates for strontium-90 is that decay may reduce the concentration of strontium-90 more efficiently than pump-and-treat can remediate the aquifer unless pumping rates were very high.

An additional source of uncertainty involves the effectiveness of full-scale precipitation followed by ion exchange to reduce the concentration of strontium-90 in extracted groundwater to the 8 pCi/L MCL established in the SDWA. These treatment technologies are well developed and demonstrated for this application but not to the SDWA MCL. Treatability studies will be required to verify the predicted effectiveness of the treatment system.

4.7.6 Alternative GW-6

The uncertainty associated with this alternative is identical to those identified for Alternative GW-5. Alternative GW-5 and GW-6 are essentially the same except for the technologies specified for treating contaminated groundwater.

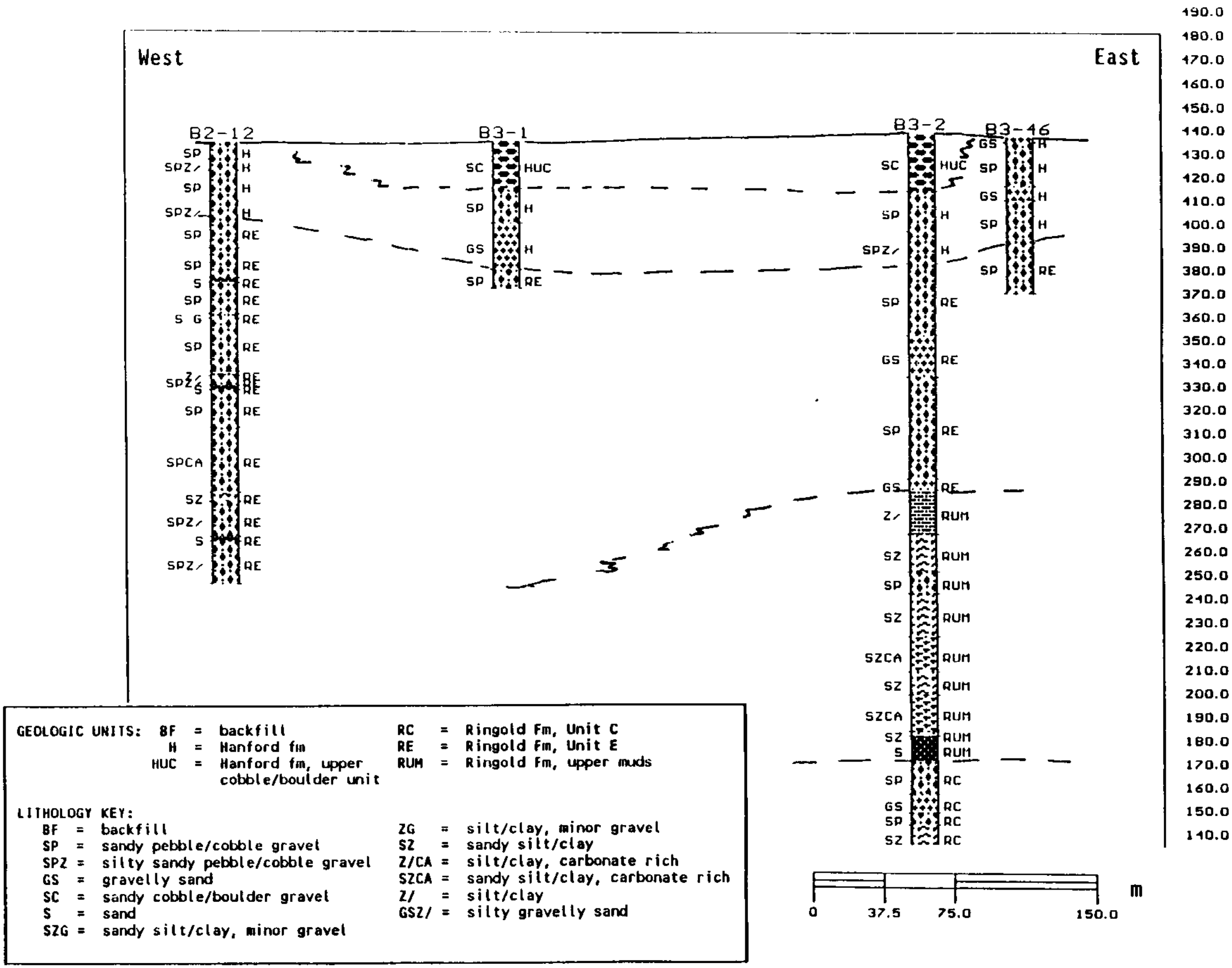


Figure 4-1 Cross-Section Through Near-River Wells

Figure 4-2 Conceptual Containment System Configuration for Alternative GW-3

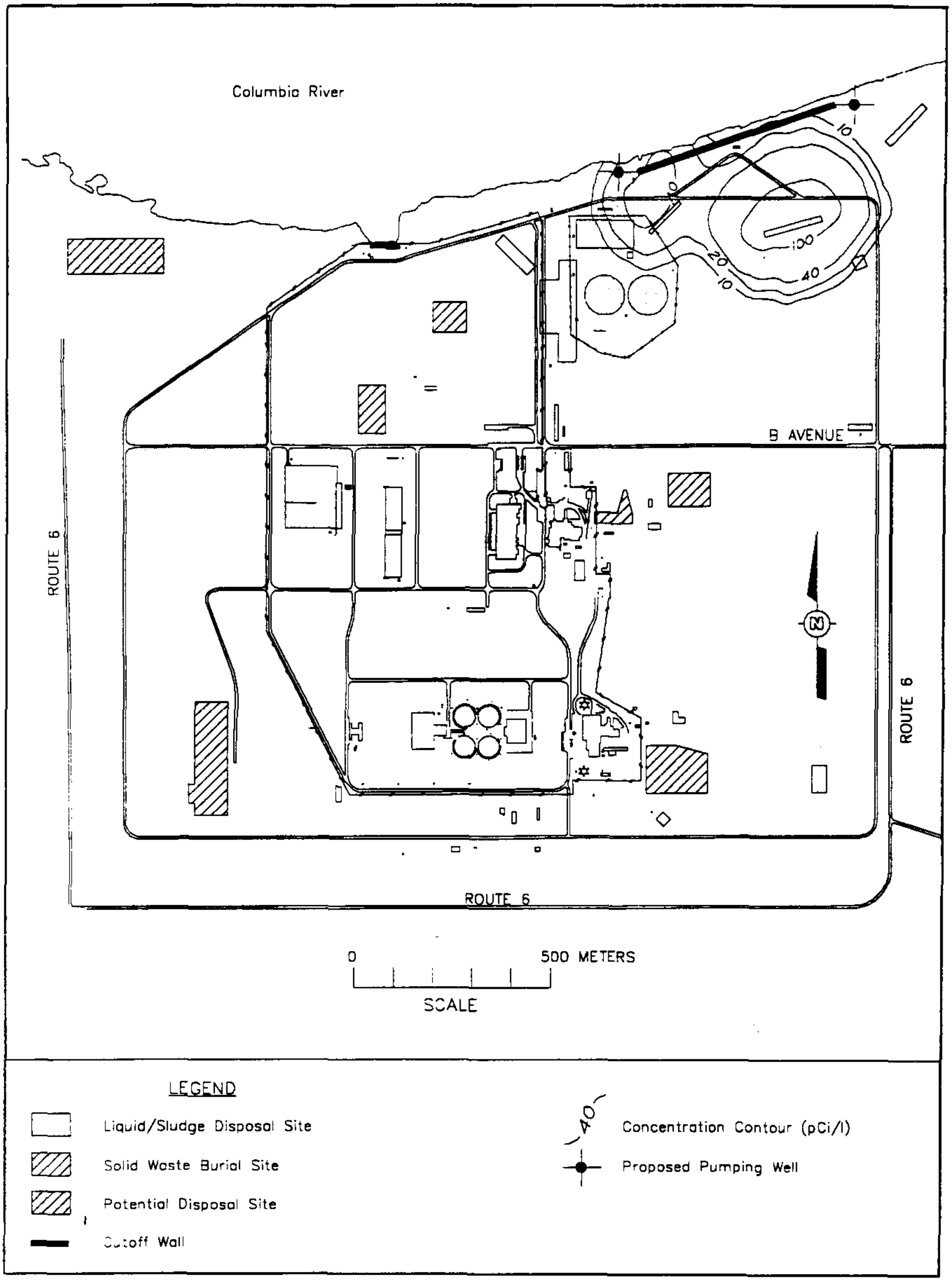


Figure 4-3 Conceptual Cutoff Wall Design for Alternative GW-3

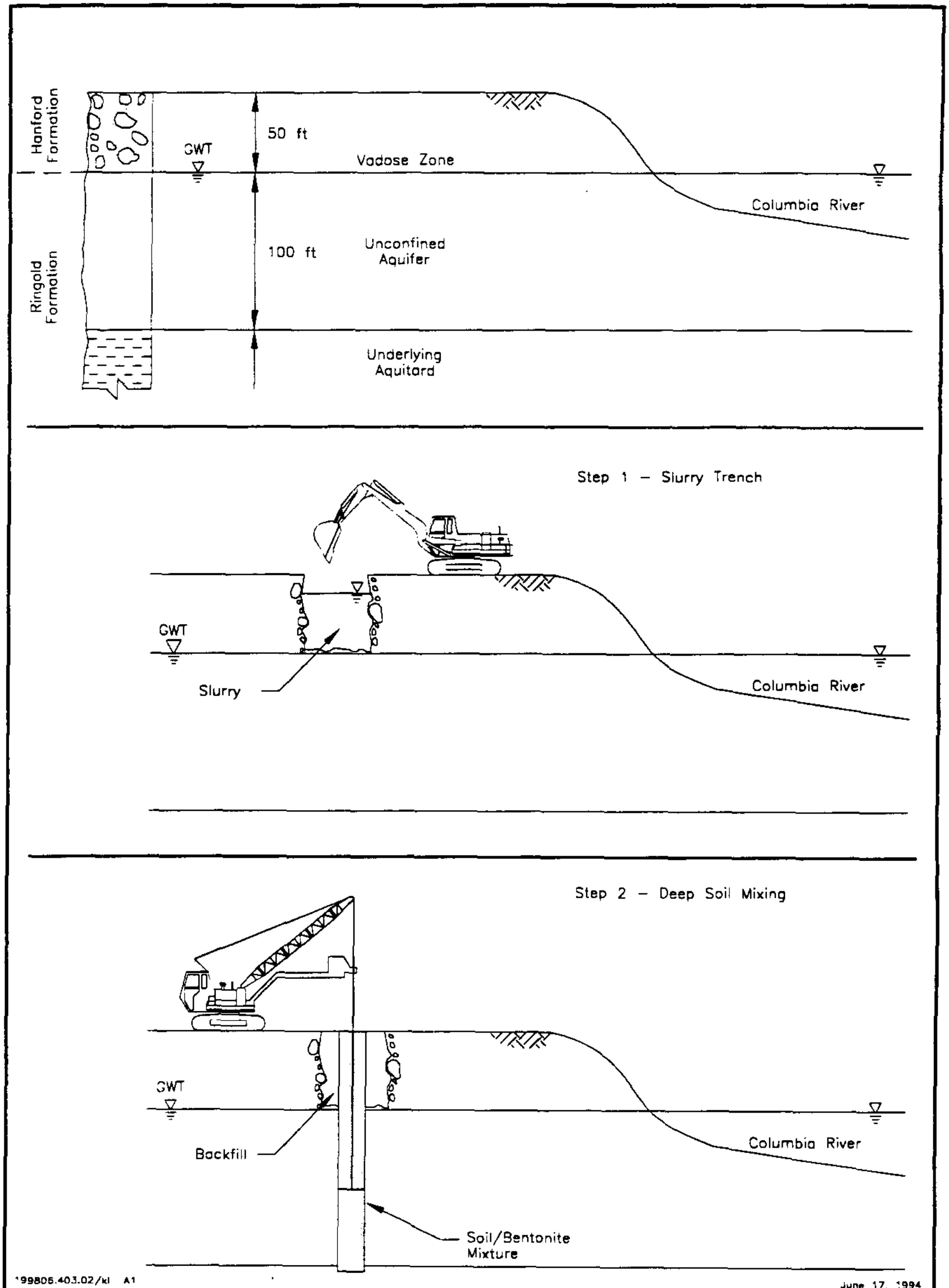
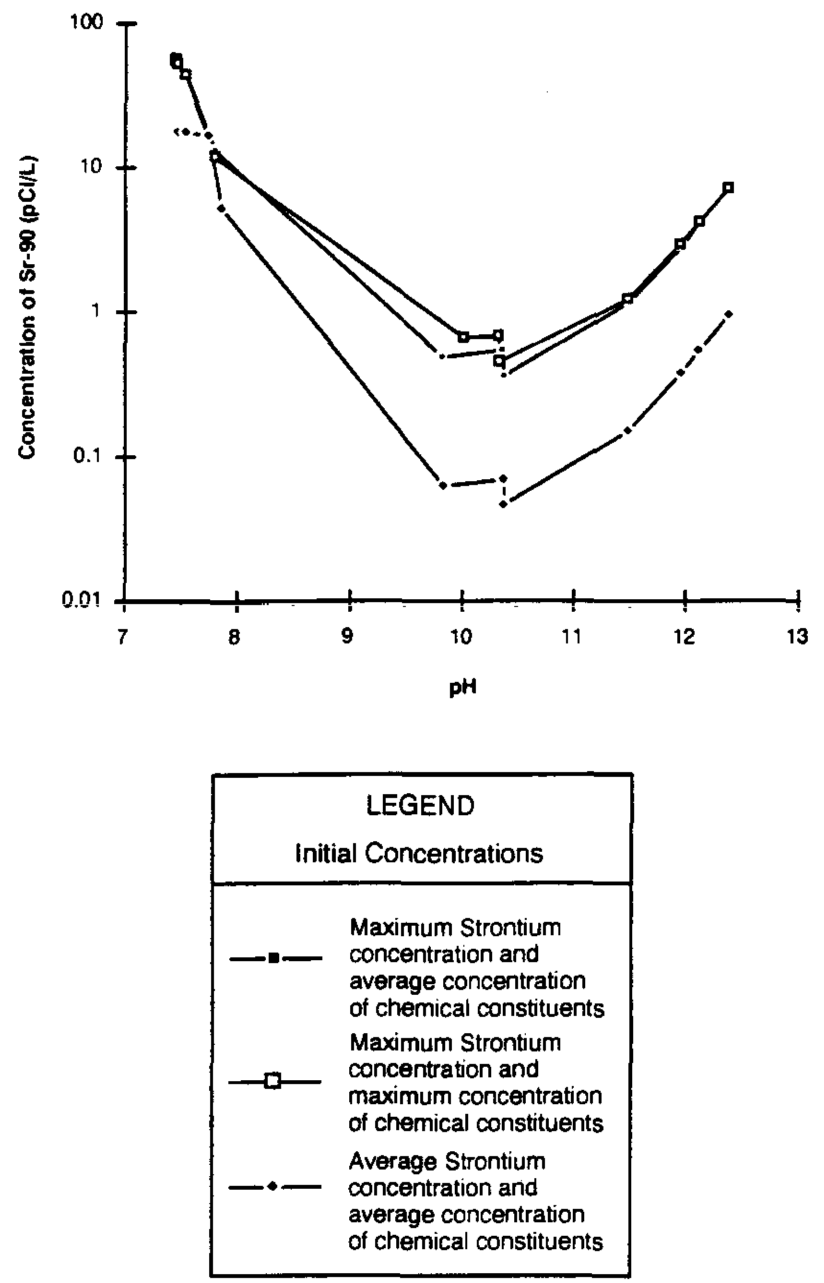
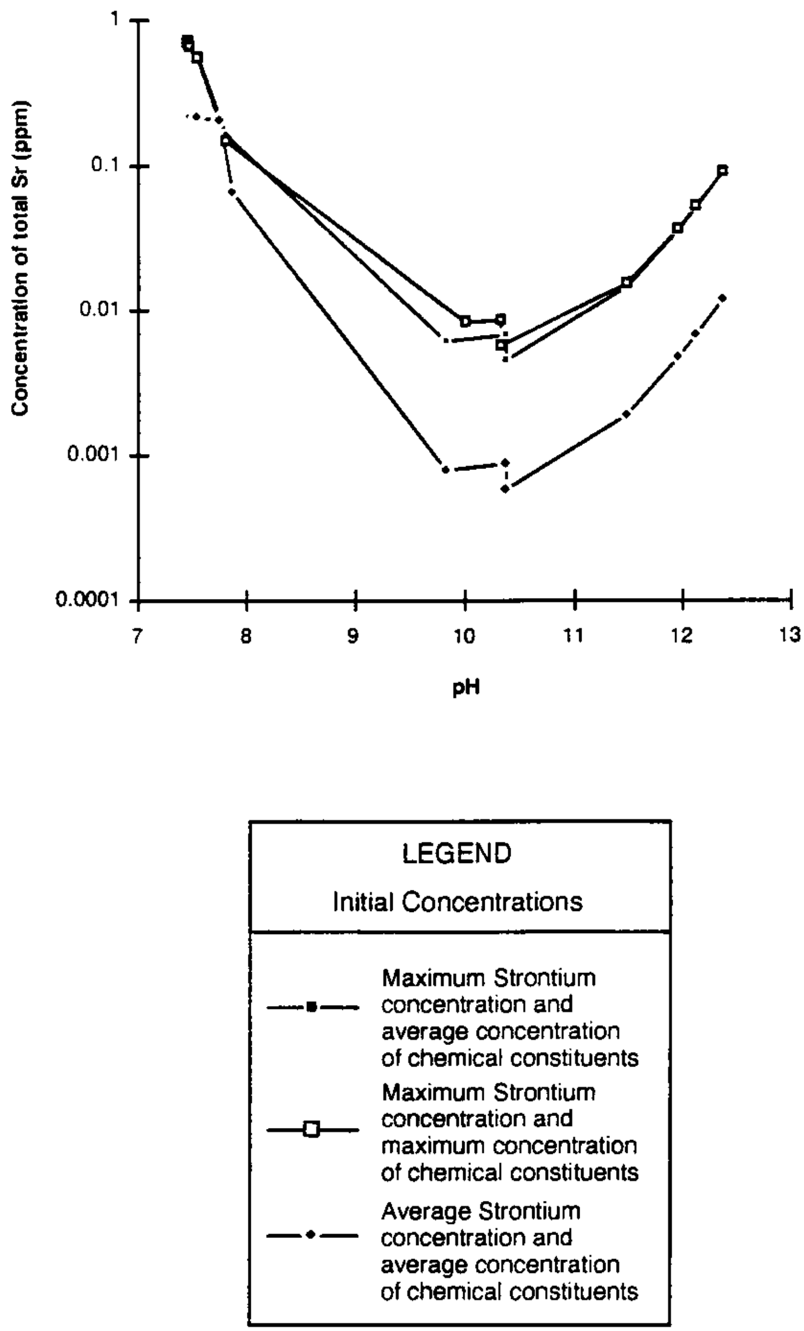


Figure 4-4 Concentration of Strontium-90 Versus pH



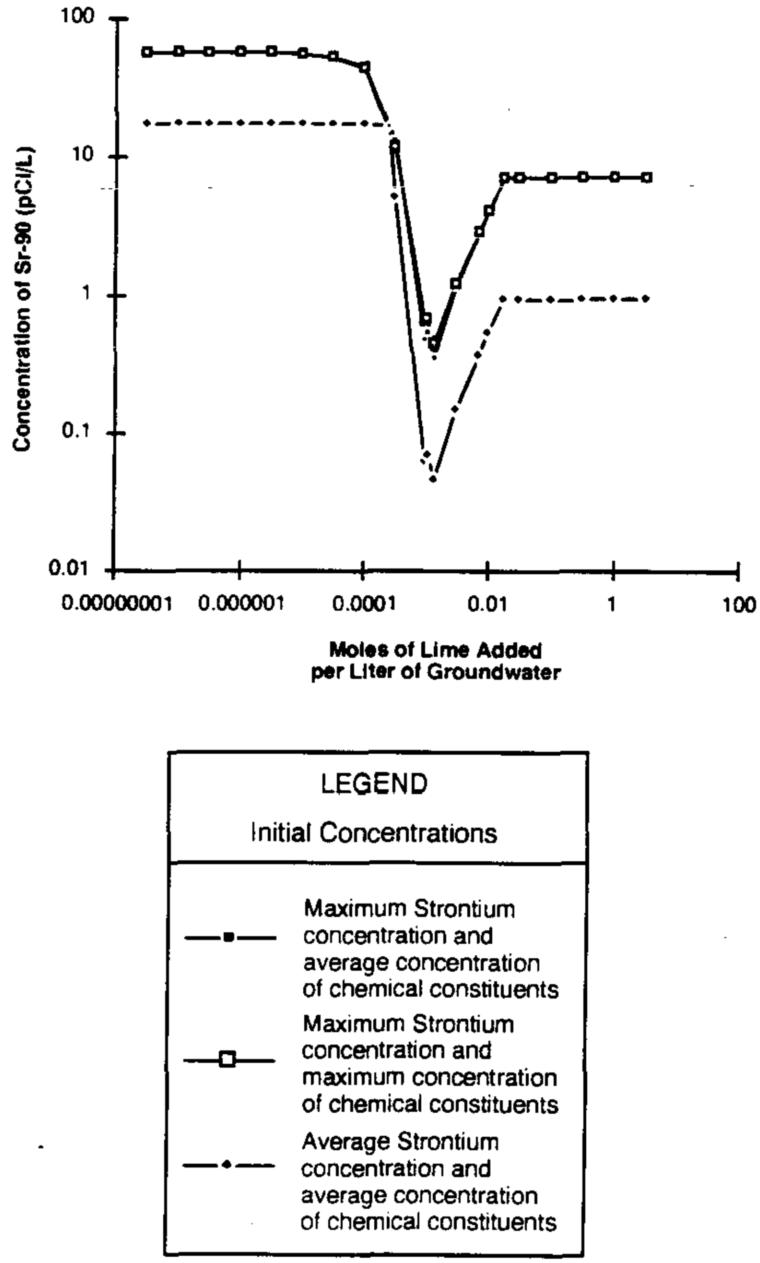
* Groundwater chemical constituent data obtained from LFI (DOE/RL-1993)

Figure 4-5 Concentration of Total Strontium Versus pH



* Groundwater chemical constituent data obtained from LFI (DOE/RL-1993)

Figure 4-6 Moles of Lime Added Versus Concentration of Strontium-90



* Groundwater chemical constituent data obtained from LFI (DOE/RL-1993)

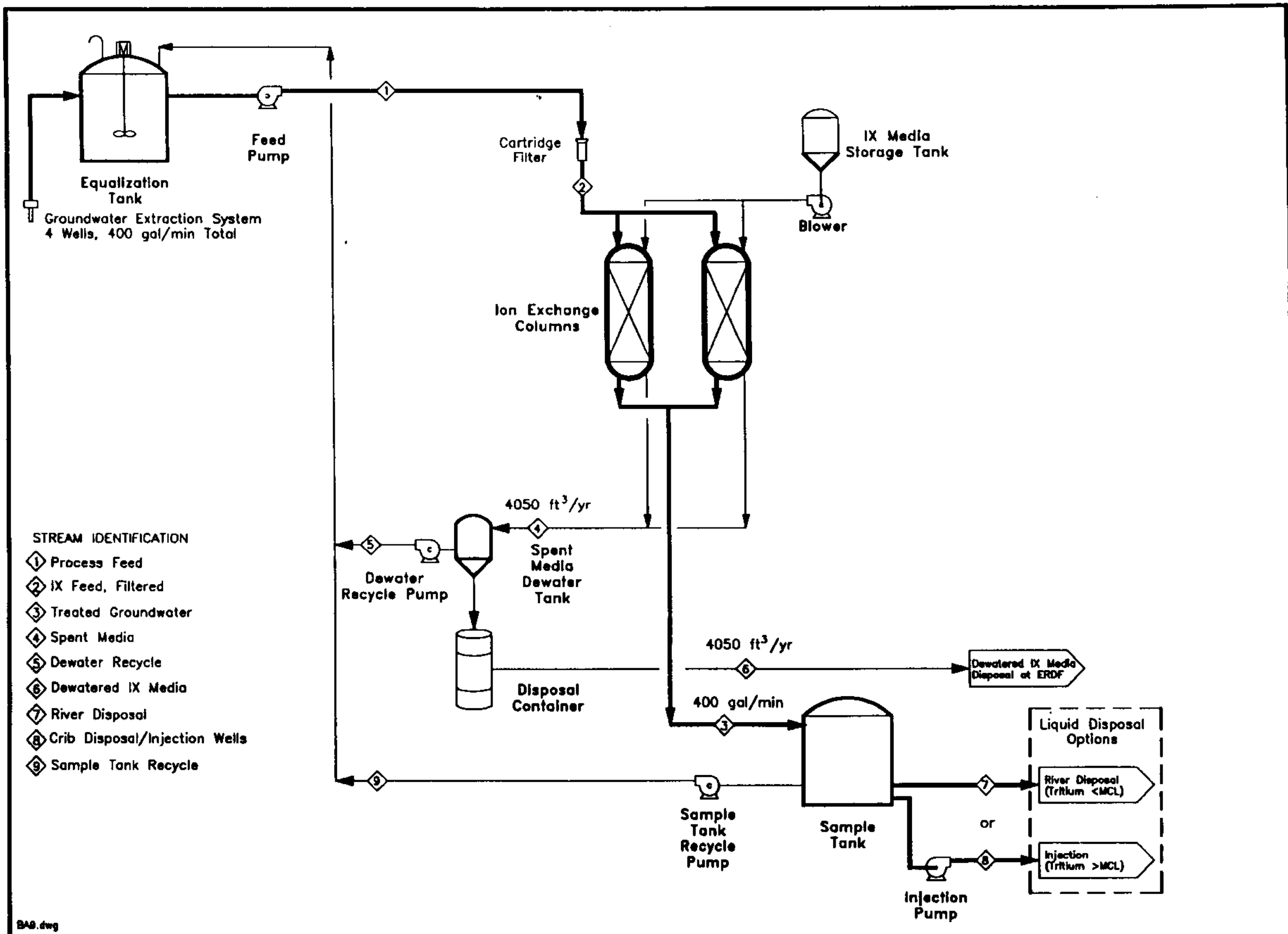
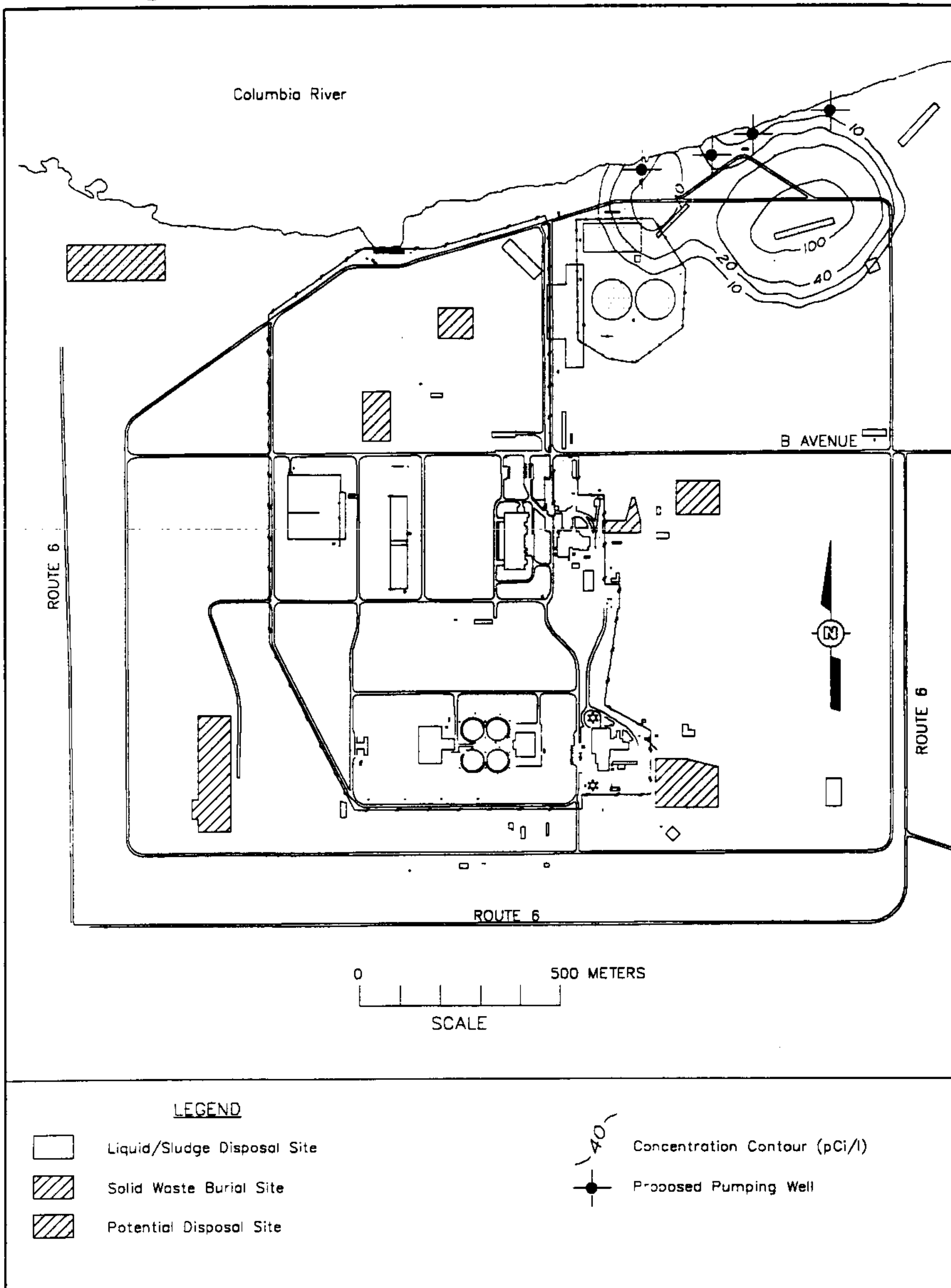


Figure 4-7 Conceptual Process Flow Diagram for Alternative GW-5

Figure 4-8 Groundwater Extraction System for Alternative GW-5



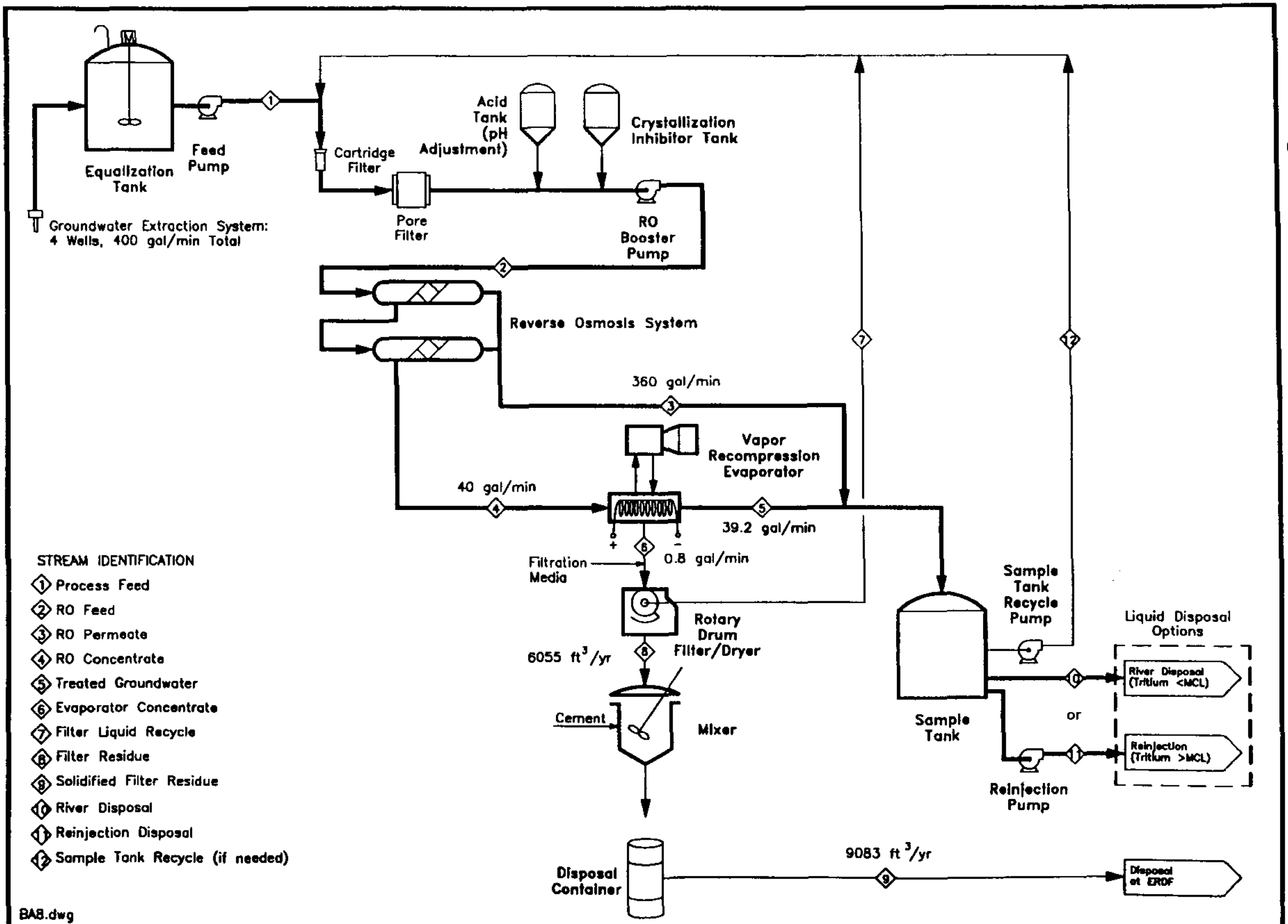


Figure 4-9 Conceptual Process Flow Diagram for Alternative GW-6

5.0 MODELING RESULTS

Numerical groundwater flow and solute transport models of the unconfined groundwater flow systems in the 100 B/C Area were developed to evaluate alternative remedial actions for minimizing further migration of strontium-90 to the Columbia River. This section describes the design of these numerical models and the assumptions used in constructing the models.

5.1 GROUNDWATER FLOW MODELS

5.1.1 Model Design

A groundwater flow model for the 100-BC-5 Operable Unit was designed and constructed with ModelCad386™, a computer-aided design software package for groundwater modeling (Geraghty and Miller, Inc 1993). ModelCad386™ has an interactive graphical interface, which provides a fast and accurate method for designing and constructing numerical groundwater flow models.

5.1.1.1 Model Code. The groundwater flow code that was used for the 100-BC-5 Operable Unit model was MODFLOW (McDonald and Harbaugh 1988), a finite-difference groundwater flow model code developed by the United States Geological Survey (USGS). MODFLOW was selected for this evaluation after a review of *Description of Codes and Models to be Used in Risk Assessment* (DOE-RL 1991b) and because it is capable of simulating the unconfined aquifer on a personal computer. The code can be linked to MT3d, a well documented transport code. Because the purpose of the modeling effort was to support detailed analysis of alternatives, a simple, personal computer-based model was desired. The intent was to quantify in relative terms the effectiveness of the alternatives. The modeling serves only as a tool for analysis.

5.1.1.2 Assumptions of Model Design. All of the hydrogeologic conditions that control the movement of groundwater in an aquifer system are not known exactly; therefore, some assumptions and simplifications must be made in constructing numerical models that simulate groundwater flow. The following assumptions were made in the construction of the groundwater flow models:

- the unconfined aquifer receives recharge by infiltration of precipitation
- there is vertical flow of groundwater between the unconfined aquifer and the underlying layers
- the Columbia River has a uniform streambed thickness and a uniform depth along the entire reach of the river within the model grid.

The scope of the modeling effort was to develop models to compare the relative effectiveness of the various alternatives, not for design purposes. Therefore, it was not feasible to model all of the details of the aquifer system, in particular, the large daily and seasonal variations in the Columbia River stage. Because all of the alternatives are simulated in the same manner and use the average river stage, the modeling is adequate for the comparison of relative effectiveness of alternatives. Because the mixing zone between the aquifer and the river was not simulated, the results are conservative, with more chromium going to the Columbia River than if the chromium was diluted in the mixing zone.

5.2 GROUNDWATER FLOW MODEL

5.2.1 Model Grid

A 106 row by 112 column, two-dimensional (one layer), finite-difference grid was constructed for the 100-BC-5 Operable Unit groundwater flow model. The grid was uniformly spaced, with a row and column spacing of 25 m (82 ft). The y-direction of the grid was oriented in a north-south direction, approximately parallel to the principal direction of groundwater flow in the 100 B/C Area.

5.2.2 Boundary Conditions

The boundary conditions of a model define the head elevation or groundwater flow rate along the boundaries of the model domain and were used to simulate hydrogeologic conditions that control the flow of groundwater in an aquifer system. The boundary conditions used in the 100 B/C Area groundwater flow model were:

- top of the model - water table (free-surface boundary)
- bottom of the model - general head (head-dependent flux)
- south boundary - constant head
- north boundary - river nodes (head-dependent flow)
- east and west boundaries - no flow (parallel to groundwater flow).

The lower boundary of the model grid was initially represented as a no-flow boundary because the unconfined aquifer in the 100 B/C Area is underlain by low hydraulic conductivity clays (DOE-RL 1993b). But in the calibration process, a general-head boundary was used to allow upward flow across the clays so that the model predicted groundwater elevations would better match observed values. This type of boundary allows flow into a cell based on the head in the lower layer and the hydraulic conductivity.

The Columbia River was simulated in the model as river nodes, a type of head-dependent flow boundary. The model adjusted the direction and rate of flow across the river nodes based on the difference in the groundwater levels simulated by the model and the stage elevations of the river nodes. When the simulated groundwater levels were higher than the stage elevations of the river nodes, flow was outward from the model along the nodes.

When the simulated groundwater levels were lower than the stage elevations of the river nodes, flow was inward to the model along the nodes. The river nodes were used to simulate, in a simplified manner, the hydraulic interaction between the Columbia River and the unconfined aquifer in the 100 B/C Area.

5.2.3 Initial Conditions

Head elevations along the constant-head boundaries and river stage elevations in the river nodes were specified as initial conditions for the 100 B/C Area groundwater flow model. The head elevations for the constant-head boundaries were estimated by constructing a groundwater elevation contour map of the unconfined aquifer from water levels measured in the monitoring wells on November 19, 1993, and projecting the elevation contours to the model grid boundaries. River stage elevations were estimated using the mean daily stage elevation recorded at the 100-B gaging station on November 19, 1993, and the river gradient calculated from a PNL river model. This gradient was verified by comparison to the gradient measured on the USGS Vernita Bridge and Coyote Rapids 1:24,000 scale topographic quadrangle maps of the area.

5.2.4 Bottom Elevations of Model Grid

A contour map of the bottom elevations of the unconfined aquifer (paleosols and overbank deposits [Lindberg 1993]) was constructed from the geologic logs of the monitoring wells in the 100 B/C Area using the computer graphics software package SURFER™ (Golden Software 1991). The bottom elevation contour map was discretized to the model grid nodes for input to MODFLOW using ModelCad386™.

5.2.5 Recharge

The aquifer recharge is reported to range from 0 to 10 cm/yr (Gee 1987). A uniform recharge of 5 cm/yr (2 in/yr) was used in the flow model. This recharge rate was determined by calibration of the flow model under steady-state flow conditions.

5.2.6 Aquifer Hydraulic Conductivity

The hydraulic conductivities of the Hanford and Ringold Formations in the 100 B/C Area are reported to range from 0.04 to 1,810 m/d (0.14 to 5,940 ft/d) (Hartman and Peterson 1992). The hydraulic conductivity in the 100 B/C Area is reported to be >4.6 m/d (15 ft/d) (DOE-RL 1993b). A hydraulic conductivity of 17 m/d (56 ft/d) was used in the flow model. This value was determined by calibration of the flow model under steady-state flow conditions. The conductance of the bottom of the model, based on model calibration, is 2 m^2/d (22 ft^2/d).

5.2.7 Storage Coefficient and Porosity

A uniform storage coefficient of 0.02 (dimensionless) and a porosity of 20% was used in the flow model for the transient simulations. The storage coefficients for the unconfined aquifer at the Hanford Site are reported to range from 0.01 to 0.2 (Hartman and Peterson 1992).

5.2.8 River Nodes

The MODFLOW River Package was used to simulate the Columbia River in the flow model. This package simulated the interaction of the Columbia River with the unconfined aquifer in the 100 B/C Area. The River Package required the following as input for each node simulating the Columbia River in the model grid:

- river stage elevation
- bottom elevation of the river bed
- hydraulic conductance of the river bed.

River stage elevations recorded at the 100 B gaging station on November 19, 1993, were used in the model. A uniform river depth of 4 m (13 ft) was assumed to estimate the elevation of the river bed bottom at each river node.

The river bed hydraulic conductance is defined by the equation (McDonald and Harbaugh 1988):

$$CRIV = KLW/M$$

where:

CRIV = hydraulic conductance of the river bed
K = vertical hydraulic conductivity of the river bed material
L = length of the river reach within the model grid cell
W = width of the river reach within the model grid cell
M = thickness of the river bed.

The hydraulic conductance of the river nodes representing the Columbia River in the flow model was calculated assuming a uniform river bed thickness of 1 m (3 ft) for the river in the 100 B/C Area. A vertical hydraulic conductivity of 1.7 m/d (5.7 ft/d) for the river bed was used in the river bed conductance calculations for the model. This vertical hydraulic conductivity was determined by calibration of the flow model under steady-state flow conditions.

5.2.9 Model Calibration

The 100 B/C Area groundwater flow model was calibrated to the water levels in the monitoring wells and the Columbia River stage elevation measured on November 19, 1993. The stage of the Columbia River, which is controlled by upstream dam releases, can vary daily from 1.8 to 2.5 m (6 to 8 ft) and seasonally from 2.5 to 3.1 m (8 to 10 ft) (DOE-RL 1993b). The November stage elevation and groundwater levels were used as calibration targets for the model because they were considered to be representative of the dynamic average or quasi-steady-state surface water and groundwater conditions at the site.

The flow model was calibrated by inputing initial estimates of recharge, aquifer hydraulic conductivity and river bed conductance into the flow model and solving the model for steady-state flow conditions. These estimated input parameters were then varied in successive simulations until the steady-state head solution output by the model reasonably matched the November 1993 water levels in the monitoring wells. When varying these parameters within reasonable limits produced groundwater elevations which were too low, the general head boundary was used to allow flow from the paleosols and overbank deposits below the unconfined aquifer. The conductance of this boundary was adjusted to provide the best match between model predicted and observed groundwater elevations.

5.3 SOLUTE TRANSPORT MODEL

5.3.1 Model Design

The 100-BC-5 Area solute transport model was designed and constructed with ModelCad386™ (Geraghty and Miller, Inc 1993).

5.3.1.1 Transport Code. The solute transport code that was used for the 100-BC-5 Area was MT3D, a finite-difference code developed by S.S. Papadopulos & Associates (1991). MT3D simulates advection, dispersion, and chemical reactions of dissolved contaminants in groundwater flow systems. The code uses a combination of the method of characteristics (MOC) and the modified method of characteristics for the solution of the advection-dispersion-reaction equation. The MOC technique was originally developed for solute transport models by the USGS (Konikow and Bredehoeft 1978). MT3D was selected for this evaluation because it is well documented, designed to be used in conjunction with the groundwater flow model code MODFLOW, and is personal computer based.

5.3.2 Technical Approach

The 100-BC-5 Area solute transport model was developed by simulating strontium-90 releases from liquid waste disposal trenches, retention basins, drains, and cribs (Figure 5-1) occurring from 1944 to 1969 and calibrating the model to strontium-90 concentrations observed in groundwater in January 1993 (DOE-RL 1993b).

The site sources that released strontium-90 into the groundwater were simulated as injection wells in the calibrated flow model. The leakage rate for each site was calculated from the total liquid waste volume the site received and the time period the site was in service (WHC 1991). This leakage rate was divided by the number of well nodes simulating the areal extent of the site to estimate the initial injection rate of each well. The calculated initial injection rates were then adjusted during the transport model calibration process.

The strontium-90 releases from the sites occurring between 1944 and 1969 were simplified in the model. Three stress periods were simulated with the following sites active during each period (no sources were active after 1968):

- 1945 - 1952: 116-B-1, 116-B-2, 116-B-11
- 1953 - 1957: 116-B-5, 116-B-10, 116-B-11, 116-C-1, 116-C-5
- 1958 - 1968: 116-B-4, 116-B-5, 116-B-10, 116-B-11, 116-C-1, 116-C-5.

A solution from a transient groundwater flow model run simulating the releases was used in the solute transport model which simulated advection, dispersion, and reaction of strontium-90 in the subsurface and estimated strontium-90 concentrations in groundwater.

An initial concentration of 7.09×10^{-13} kg/m^3 (0.1 pCi/mL) was input at the injection well nodes simulating the point sources of the releases and then adjusted in the calibration process. The solute transport simulations were run using a porosity of 20%, longitudinal to transverse dispersivities of 10 to 1 m (32.8 to 3.3 ft), a retardation factor of 213, and a half life of 28.1 years. A low estimate of the distribution coefficient of 20 mL/g (0.02 m^3/kg) (Ames and Serne 1991) was used to calculate the retardation factor because it represents a conservative approach in simulating concentrations of strontium-90 in the groundwater. A bulk density of 2,120 kg/m^3 was used.

Because of the high strontium-90 retardation factor, the transport model solutions were less sensitive to porosity and dispersivity and more sensitive to the source strength. The transport model calibration was based on adjusting the source strength by varying the leakage rate of the injection well nodes and the initial concentrations of the point sources. The model-simulated strontium-90 solute concentrations were compared with the concentrations observed in groundwater in January 1993 (DOE-RL 1993b). The strontium-90 concentration contour map from the calibrated transport model solution is presented in Figure 5-2.

5.4 MODELING RESULTS

5.4.1 GW-1 and GW-2: No Action and Institutional Controls/Continued Current Actions Alternatives

For the no action and institutional controls/continued current actions alternatives, the calibrated strontium-90 plume was migrated to the years 2008 and 2018 using the flow field solution from the calibrated steady-state groundwater flow model. The strontium-90 concentrations calculated by the calibrated transport model were used as the initial concentrations for the solute transport simulations of all three remedial alternatives. The transport simulations were run using a porosity of 20%, longitudinal to transverse dispersivities of 10 to 1 m (32.8 to 3.3 ft) and a retardation factor of 213.

The strontium-90 concentration contour maps from the transport simulation solutions are shown in Figures 5-3 and 5-4. In the no action simulations, 0.07 Ci of strontium-90 are discharged into the river nodes simulating the Columbia River in the year 2008 simulation and 0.1 Ci in the year 2018 simulation.

5.4.2 GW-3: Vertical Barrier Alternative

The vertical barrier alternative consisted of a vertical, low permeability wall placed near the Columbia River, which would act as a barrier for the further migration of contaminated groundwater into the river. In the model, a single groundwater extraction well was simulated at each end of the vertical barrier to minimize migration of groundwater around the ends of the wall.

For the barrier wall simulations, the calibrated groundwater flow model was modified by changing the aquifer hydraulic conductivity in a line of grid nodes along the Columbia River (Figure 5-5) to 1×10^{-6} cm/s to represent the barrier wall. Based on the grid size, the effective width of the wall is 25 m (82 ft) and the wall is 450 m (1,500 ft) long. Two well nodes were also added to the model near the ends of the simulated barrier wall to represent the groundwater extraction wells.

The location of the barrier wall and the discharge rates of the well nodes were varied in successive simulations to maximize plume capture and minimize the additional leakage of water from the river nodes simulating the Columbia River due to the pumping well nodes. A particle tracking program PATH3D (Zheng 1991) simulating advective movement of contaminant solutes in groundwater was used to delineate the capture zone. The discharge rate of the well nodes was set at 544 m^3/d (100 gpm) to ensure the plume capture (Figure 5-6).

Plume migration was then simulated to the years 2008 and 2018 using the flow field solution from the modified calibrated groundwater flow model. Transport simulations were run using the same range of transport parameters as for the no action alternative.

The strontium-90 concentration contour maps from the barrier wall simulation solutions using porosity of 20%, longitudinal dispersivity of 10 m (32.8 ft), transverse dispersivities of 1 m (3.3 ft), and a retardation factor of 213 are presented in Figures 5-7 and 5-8. The water table map for the year 2008 simulation is shown in Figure 5-9. In the barrier wall simulation, 0.008 Ci of strontium-90 are discharged into the river nodes simulating the Columbia River in the year 2008 simulation and 0.01 Ci in the year 2018 simulation. The amount of strontium discharging into the river is reduced by 87%. In comparison to the no action alternative, these simulations indicate that a vertical barrier wall would be effective in reducing further migration of contaminated groundwater into the Columbia River.

5.4.3 GW-5 and GW-6: Removal, Treatment, Disposal Alternatives

Simulation of the groundwater extraction and treatment alternative consisted of a line of extraction wells along the Columbia River to control further migration of the contaminated groundwater into the river.

For the groundwater extraction and treatment simulations, the calibrated groundwater flow model was modified by adding four well nodes to the model to represent the boundary control extraction wells. Four well nodes were placed along the Columbia River (Figure 5-10). The location, spacing and discharge rates of these well nodes were varied in successive simulations to maximize plume capture and to minimize the additional leakage of water from the river nodes simulating the Columbia River due to the well nodes (minimize the uptake of river water by the boundary control wells). In order to confirm that plume capture was established at relatively low drawdowns in the well nodes of approximately 0.6 m (2 ft), the particle tracking program PATH3D simulating advective movement of contaminant solutes in groundwater was used. Figure 5-11 shows results of a particle tracking simulation using the modified calibrated groundwater flow model. A well spacing of approximately 100 m (328 ft) with discharge rates 544 m^3/day (100 gpm) maximized the plume capture and minimized the additional river leakage in the model due to the well nodes.

Plume migration was then simulated to the years 2008 and 2018 using the flow field solution from the modified calibrated groundwater flow model. Transport simulations were run using the same range of transport parameters as for the no action alternative.

The strontium-90 concentration contour maps from the extraction and treatment simulation solutions using porosity of 20%, longitudinal dispersivity of 10 m (32.8 ft), transverse dispersivities of 1 m (3.3 ft), and a retardation factor of 213 are presented in Figures 5-12 and 5-13. The water table map for the year 2008 simulation is shown in Figure 5-14. In the extraction and treatment simulations, 0.004 Ci of strontium-90 is discharged into the river nodes in the year 2008 simulation and 0.007 Ci in the year 2018 simulation. The amount of strontium discharging into the river is reduced by 93%. In comparison to the no action simulations, these simulations indicate that a groundwater extraction and treatment system would be effective in minimizing further migration of contaminated groundwater into the Columbia River.

Figure 5-1 100-BC-5 Operable Unit Base Map

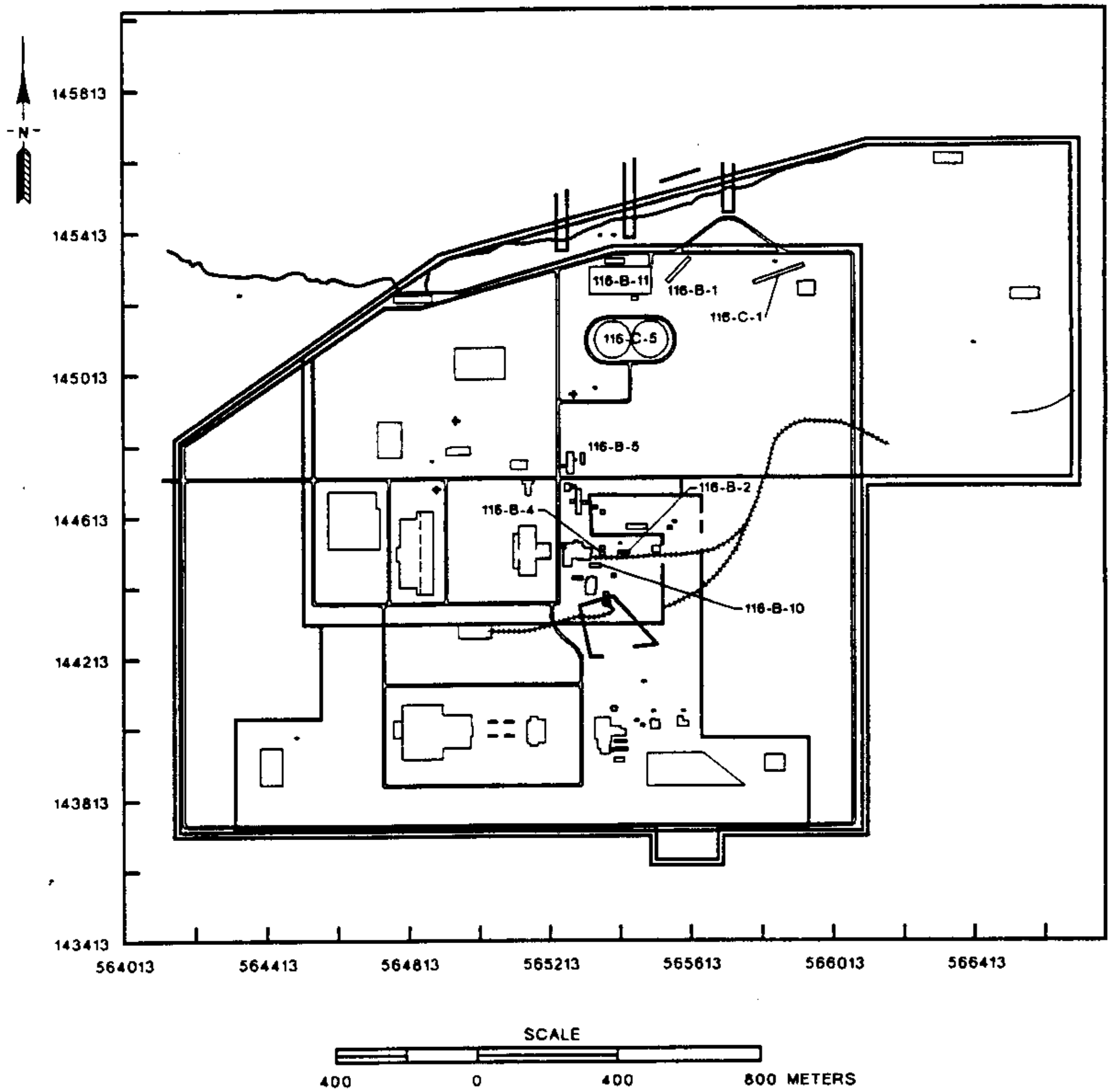


Figure 5-2 Simulated Strontium-90 Concentration Map

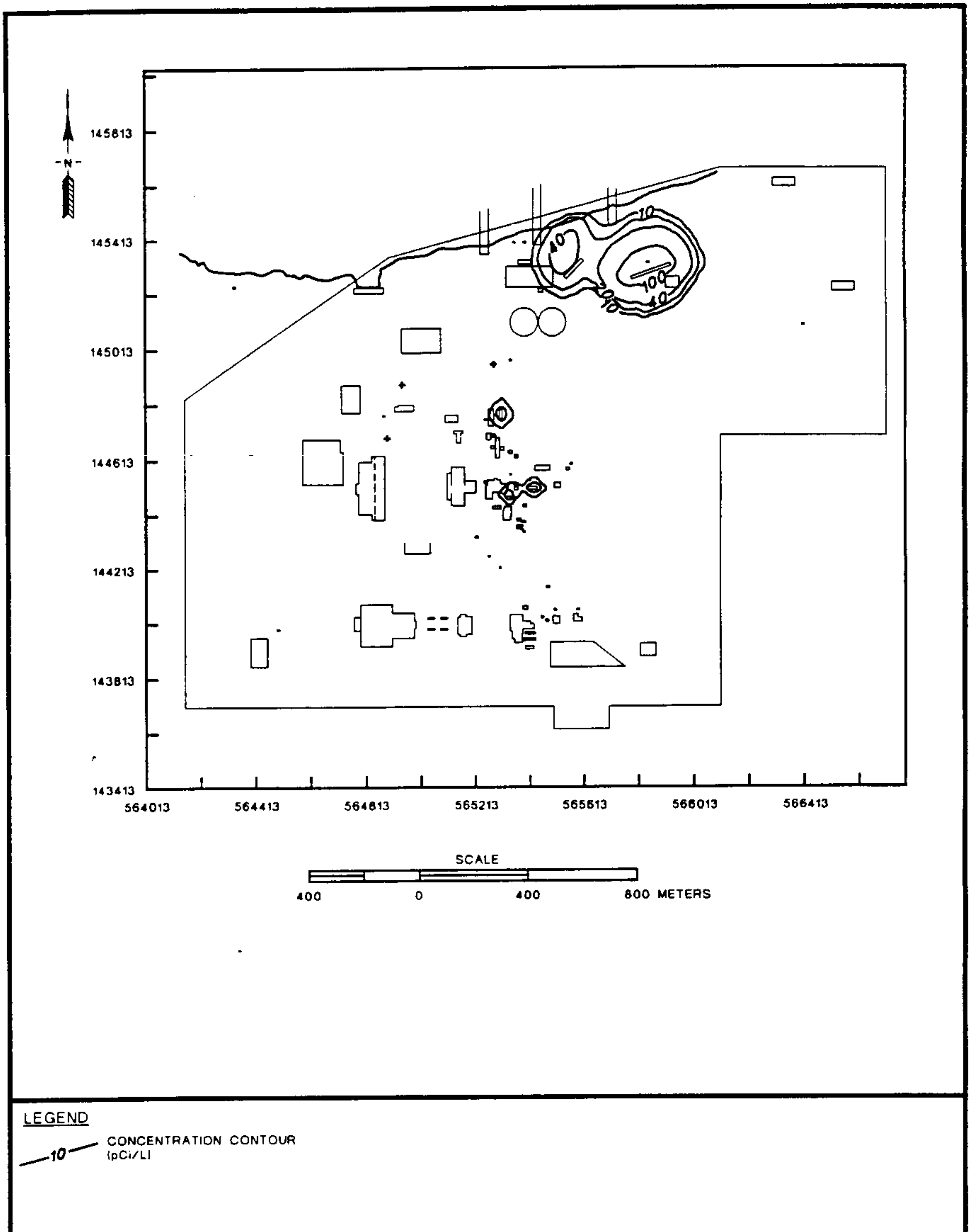


Figure 5-3 No Action Alternative Simulated Strontium-90 Concentration Map

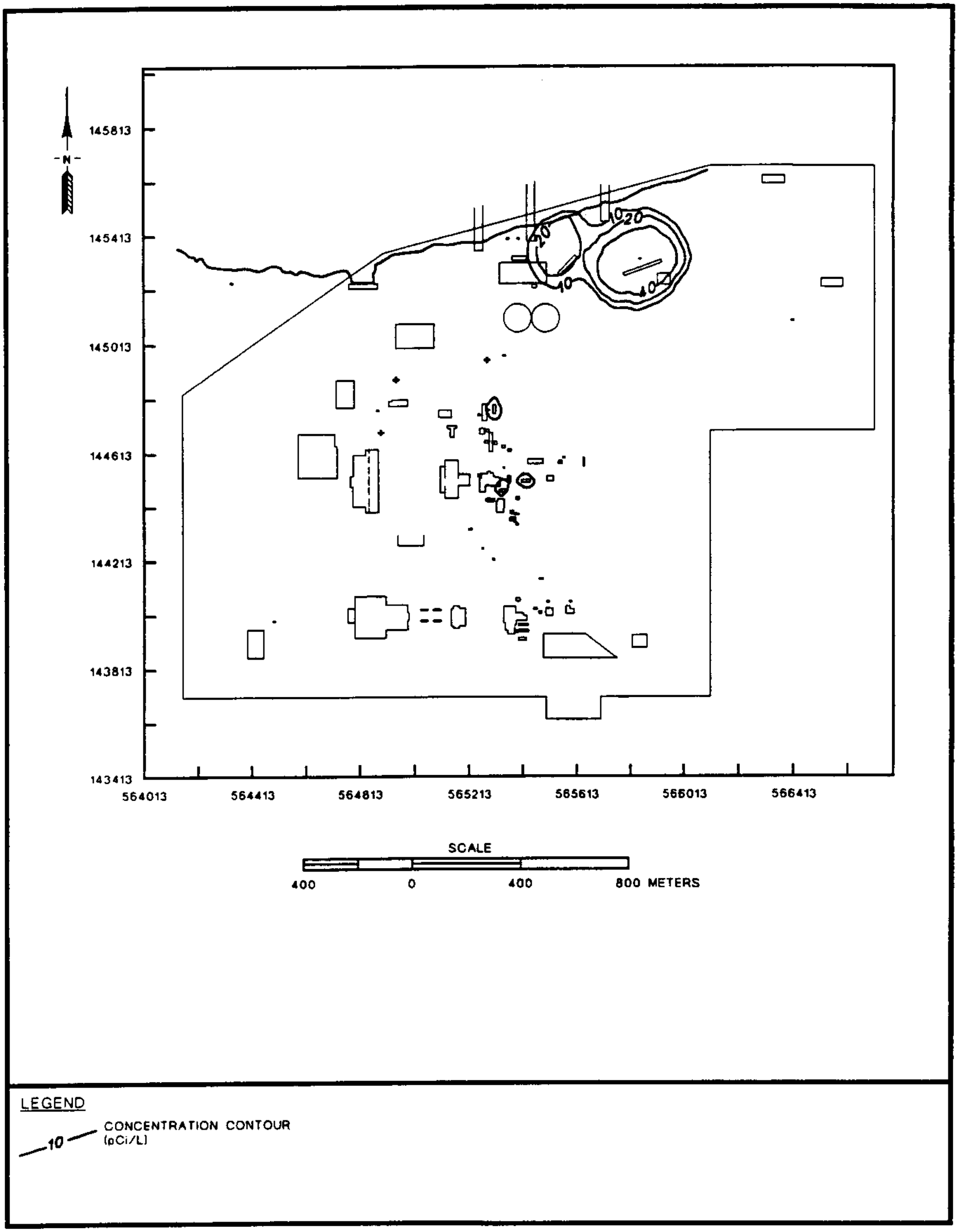


**Figure 5-4 No Action Alternative Simulated Strontium-90 Concentration Map
25 Year Simulation**

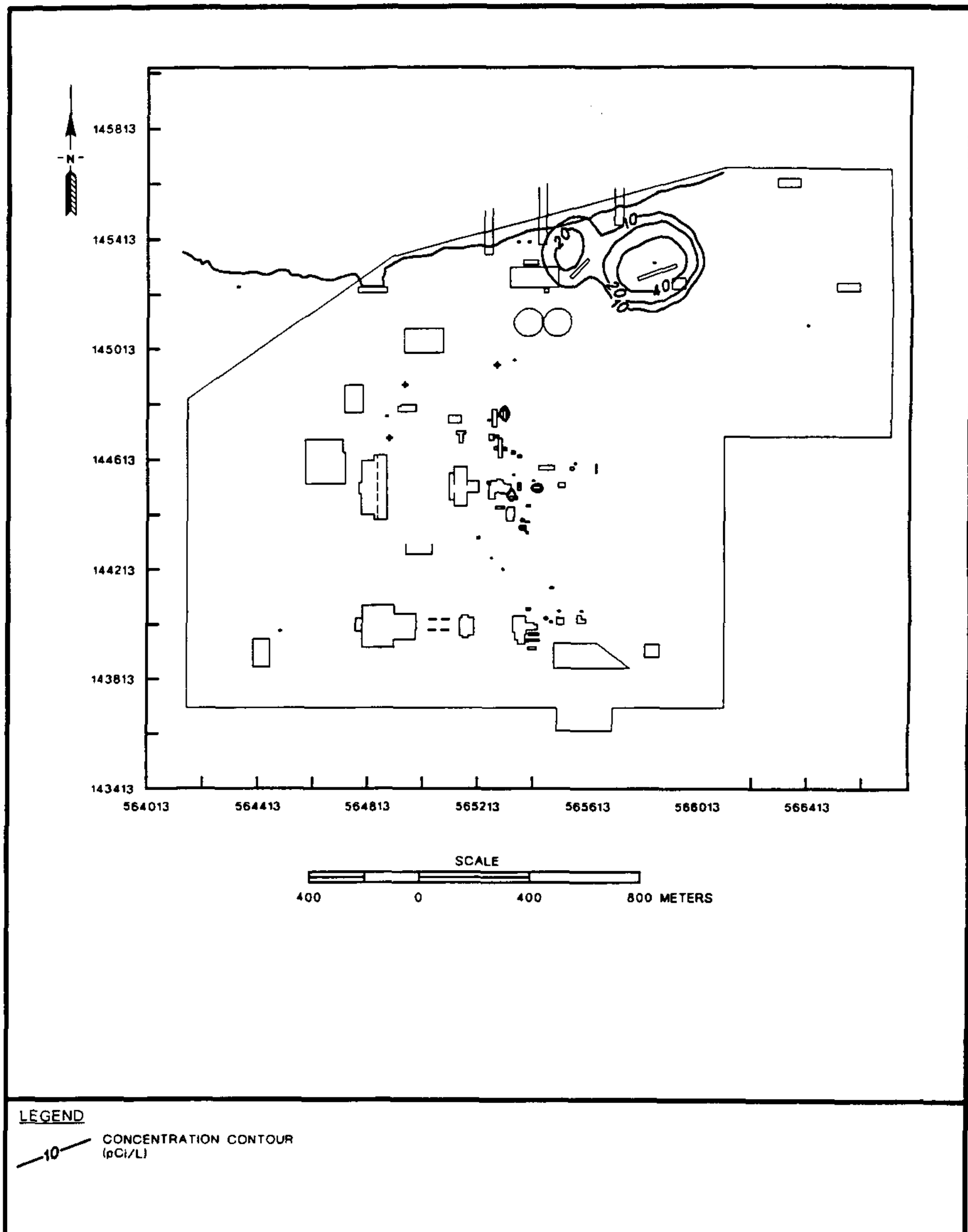


Figure 5-5 Vertical Barrier Location and Initial Concentration Map

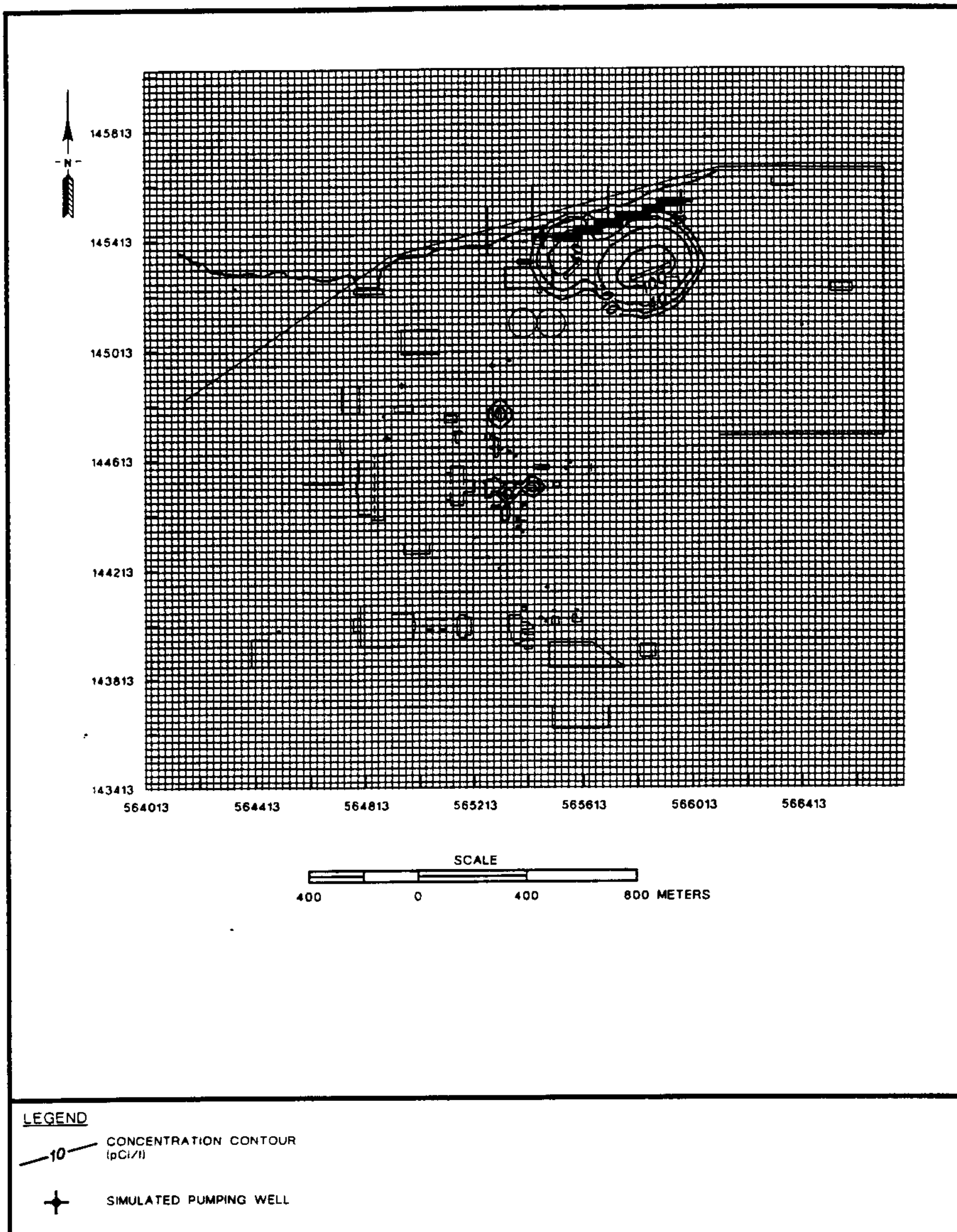
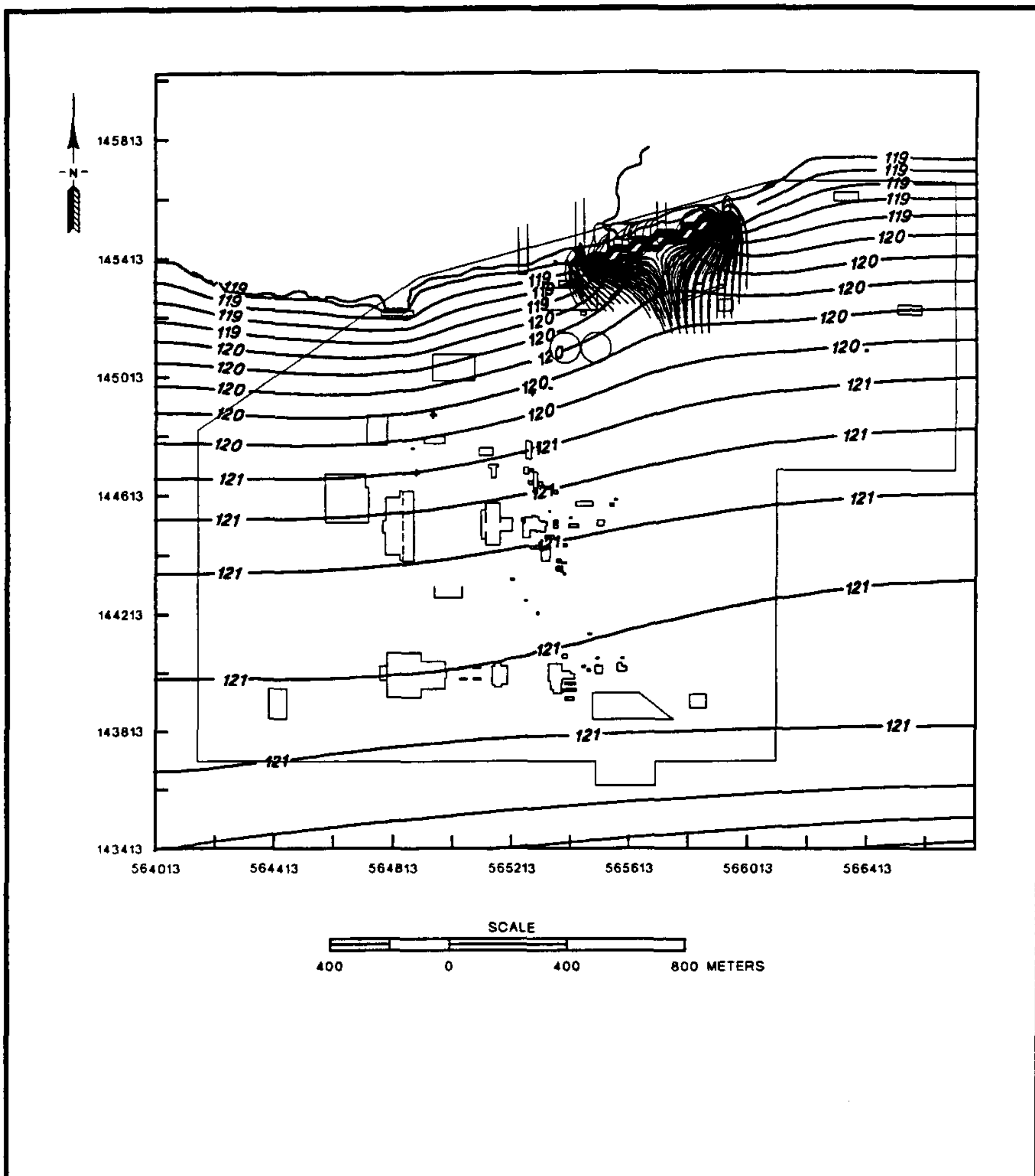


Figure 5-6 Vertical Barrier Alternative Simulated Plume Capture with Particle Tracking, 15 Year Simulation



LEGEND

119 WATER LEVEL ELEVATION CONTOUR (m)

**Figure 5-7 Vertical Barrier Alternative Simulated Strontium-90 Concentration Map
15 Year Simulation**

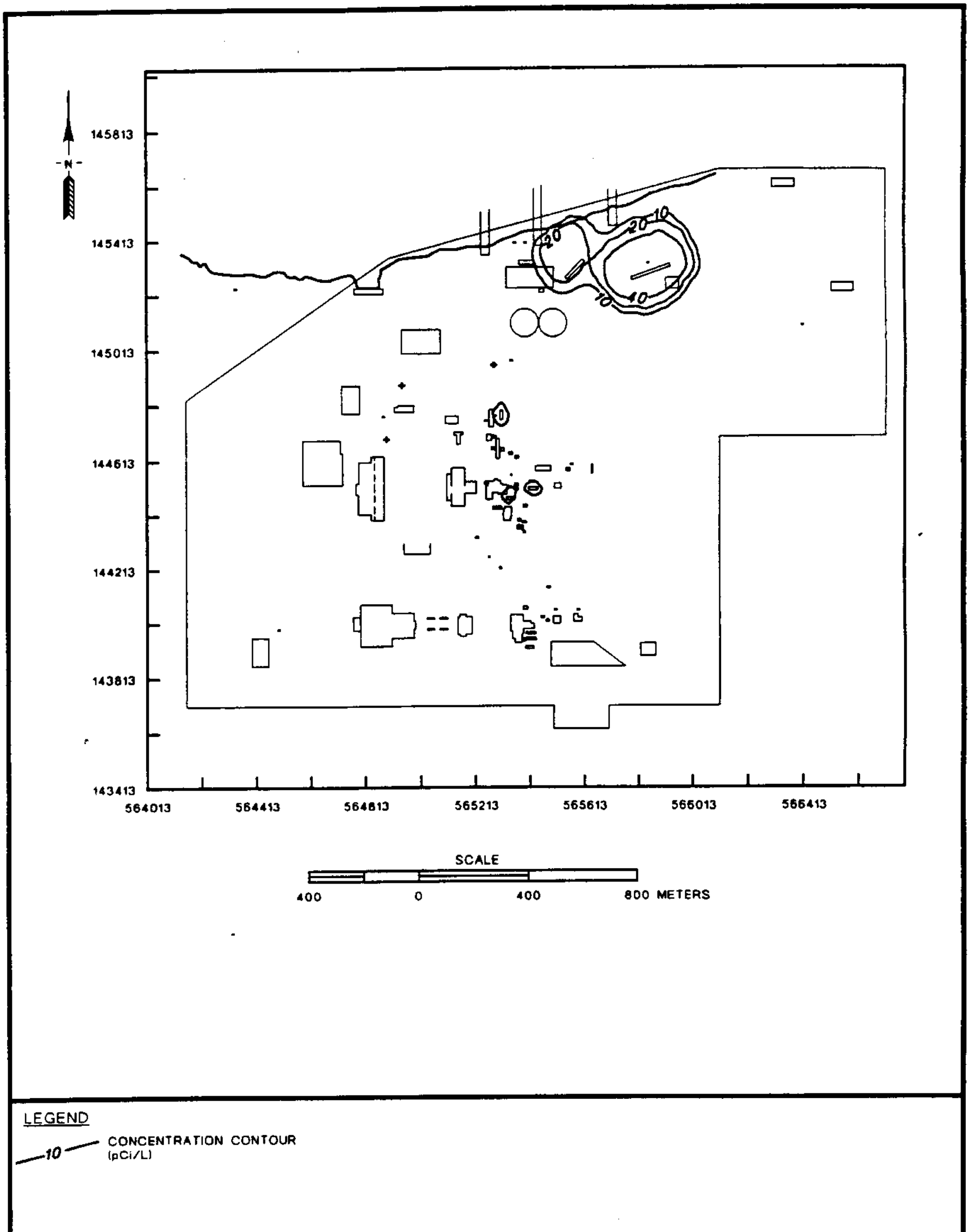


Figure 5-8 Vertical Barrier Alternative Simulated Strontium-90 Concentration Map 25 Year Simulation

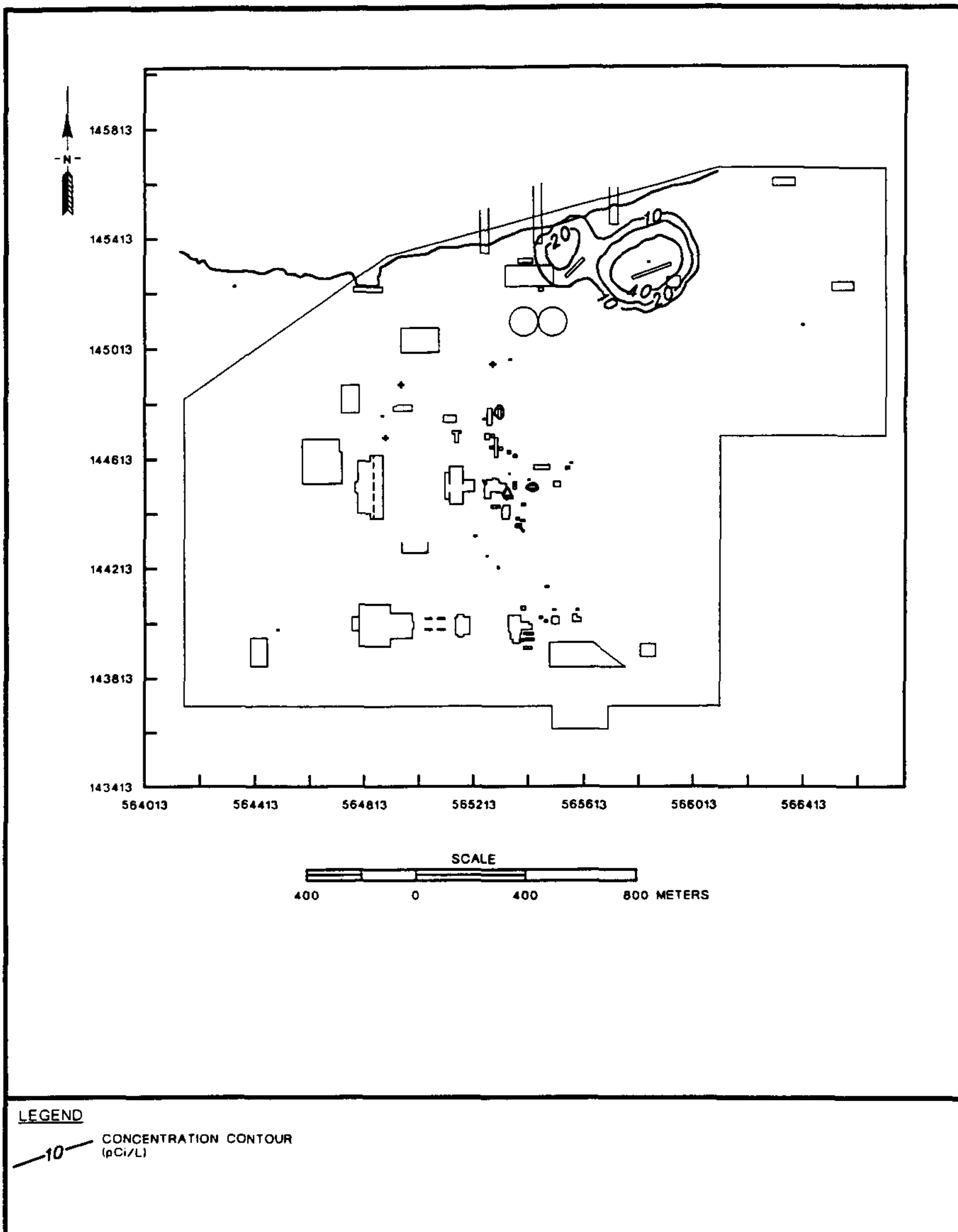


**Figure 5-9 Vertical Barrier Alternative Water Table Contour Map
15 Year Simulation**

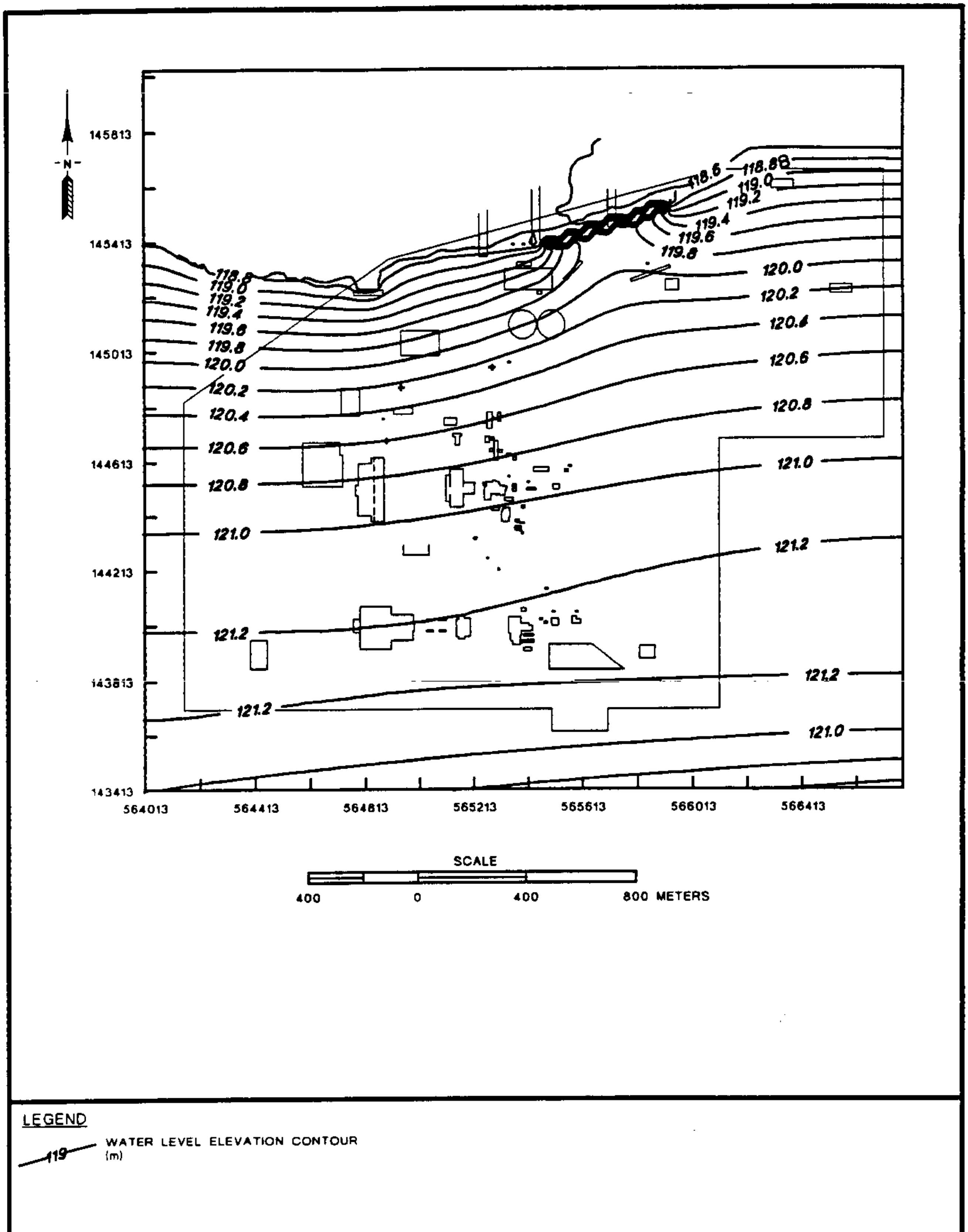


Figure 5-10 Groundwater Extraction Well Locations and Initial Concentration Map

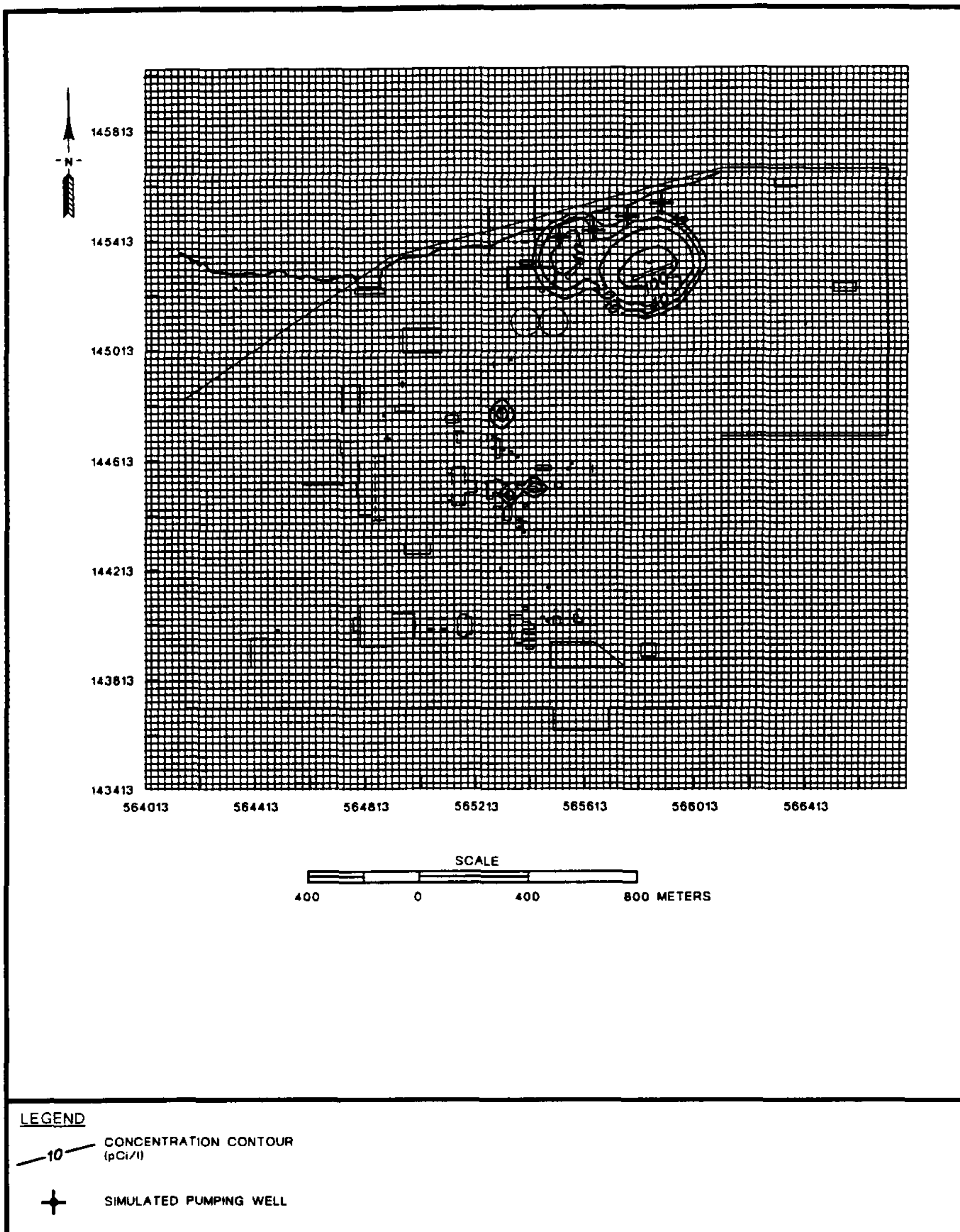


Figure 5-11 Groundwater Extraction Alterative Simulated Plume Capture with Particle Tracking, 15 Year Simulation

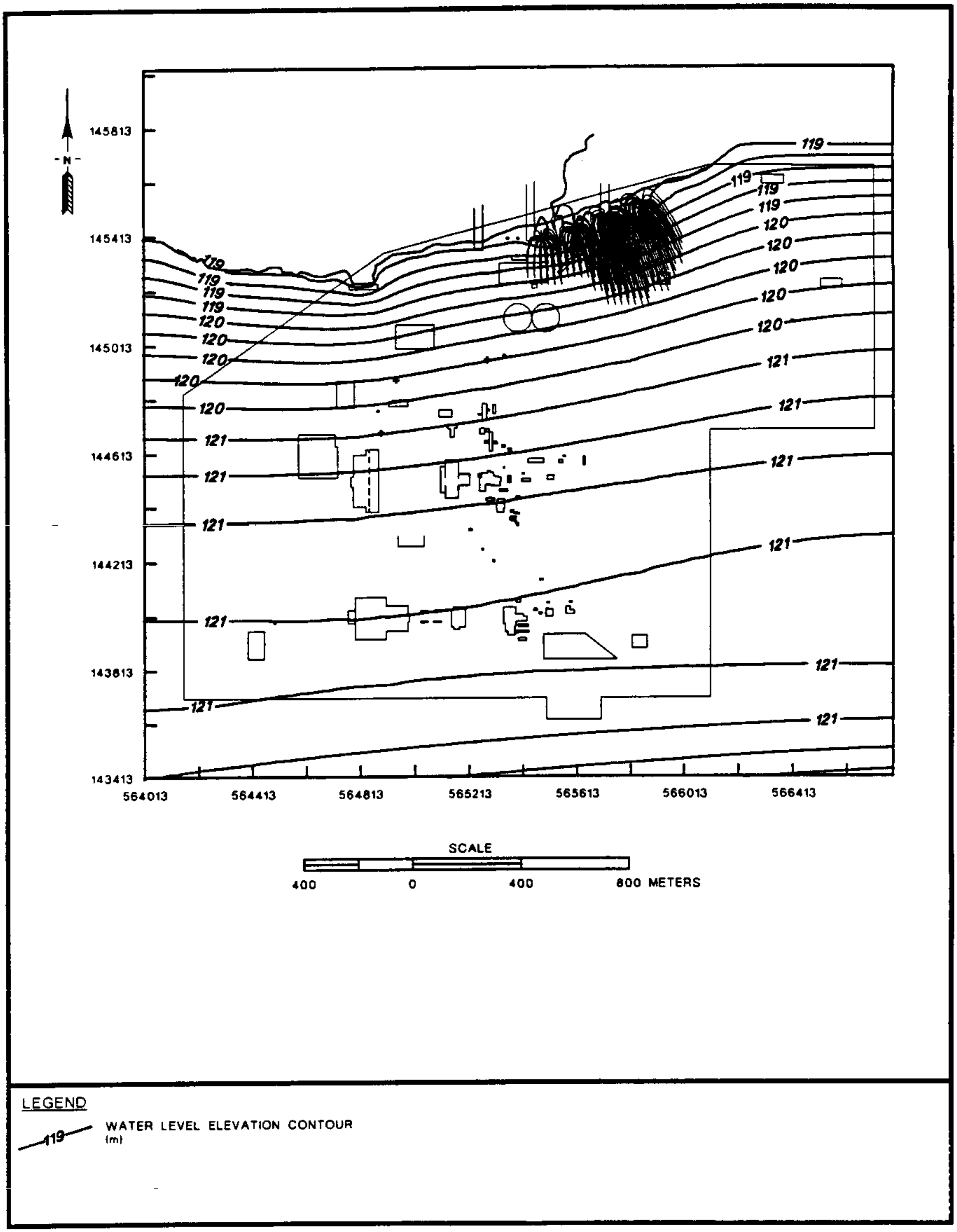


Figure 5-12 Groundwater Extraction Alternative Simulated Strontium-90 Concentration Map, 15 Year Simulation

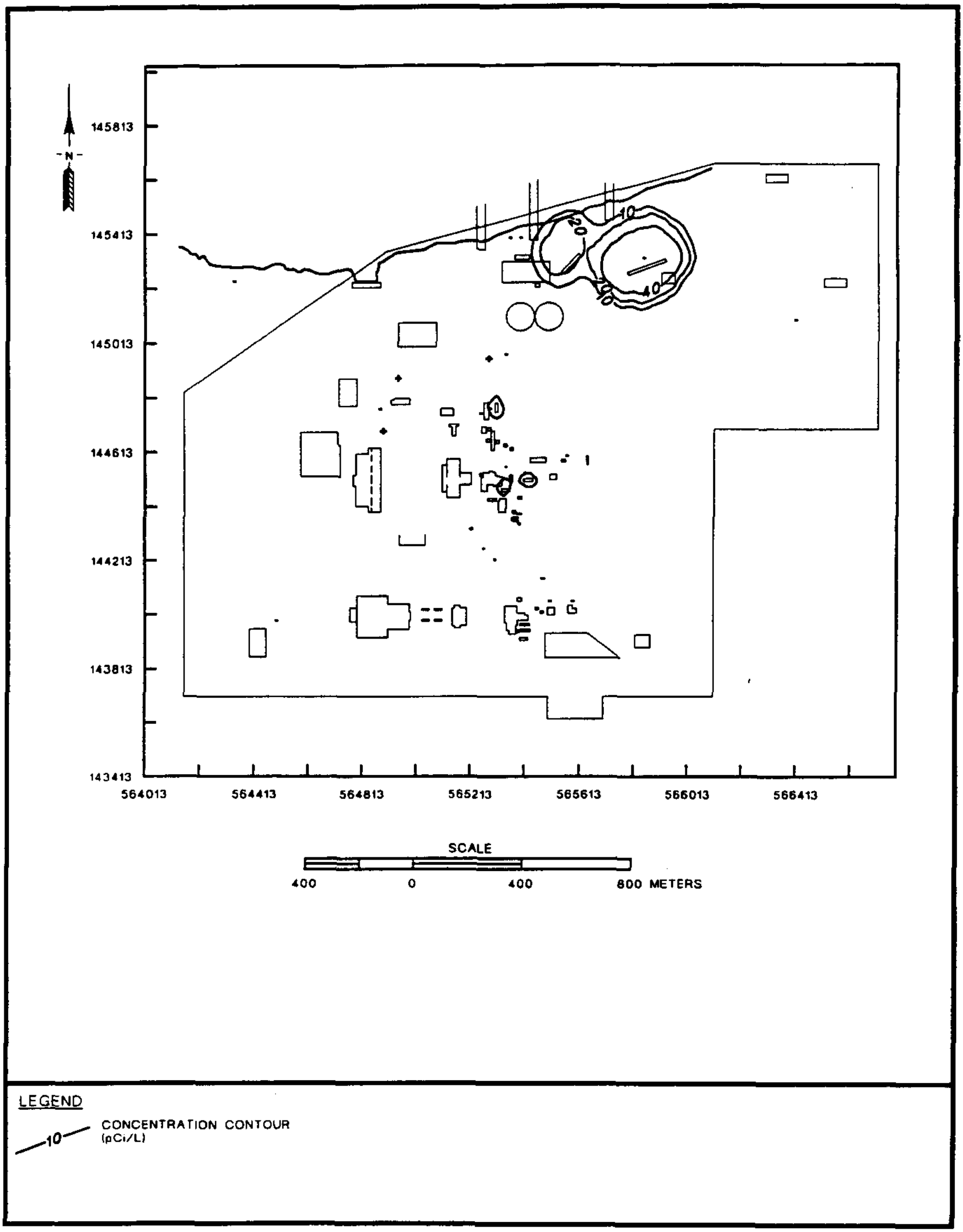


Figure 5-13 Groundwater Extraction Alternative Simulated Strontium-90 Concentration Map, 25 Year Simulation

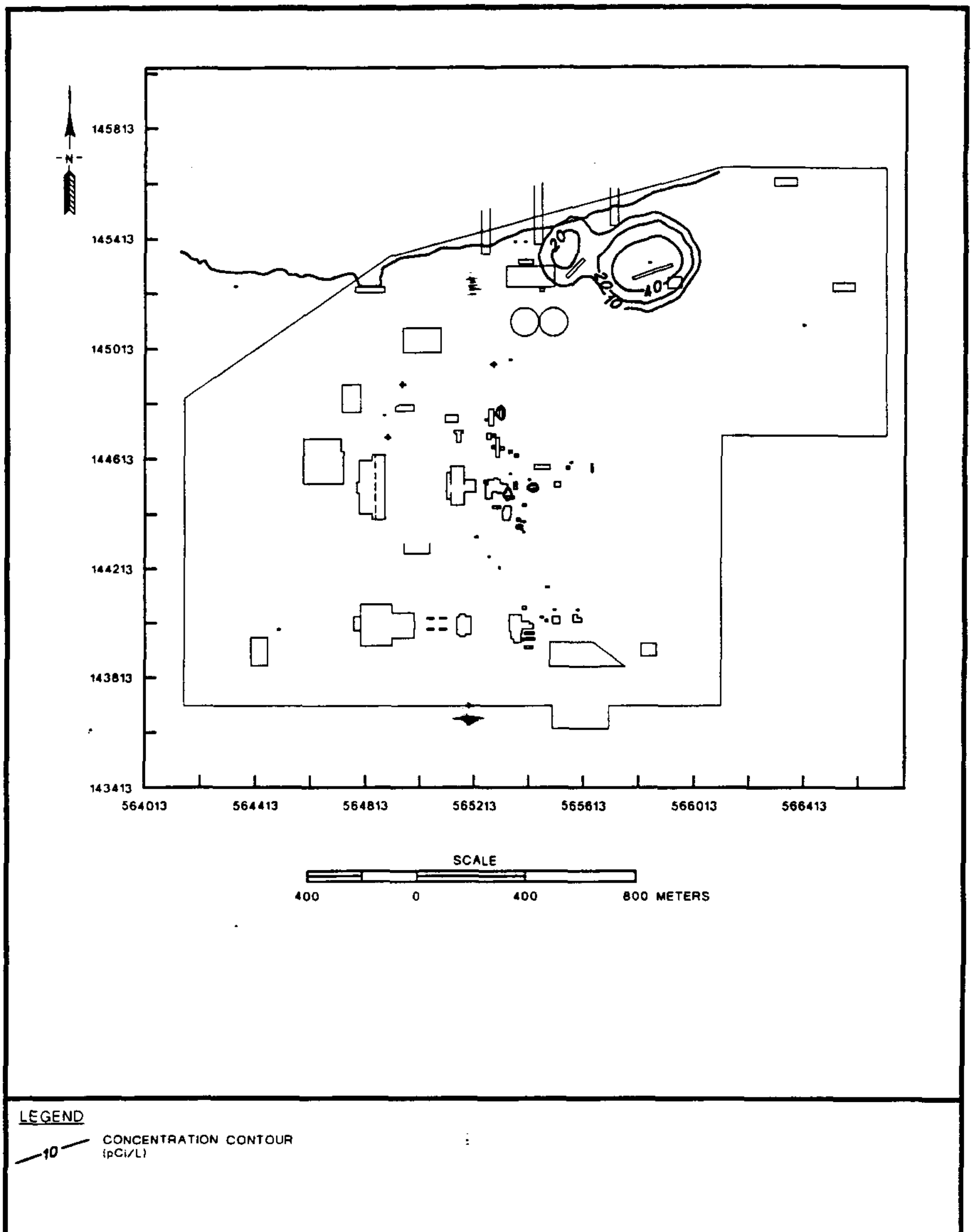
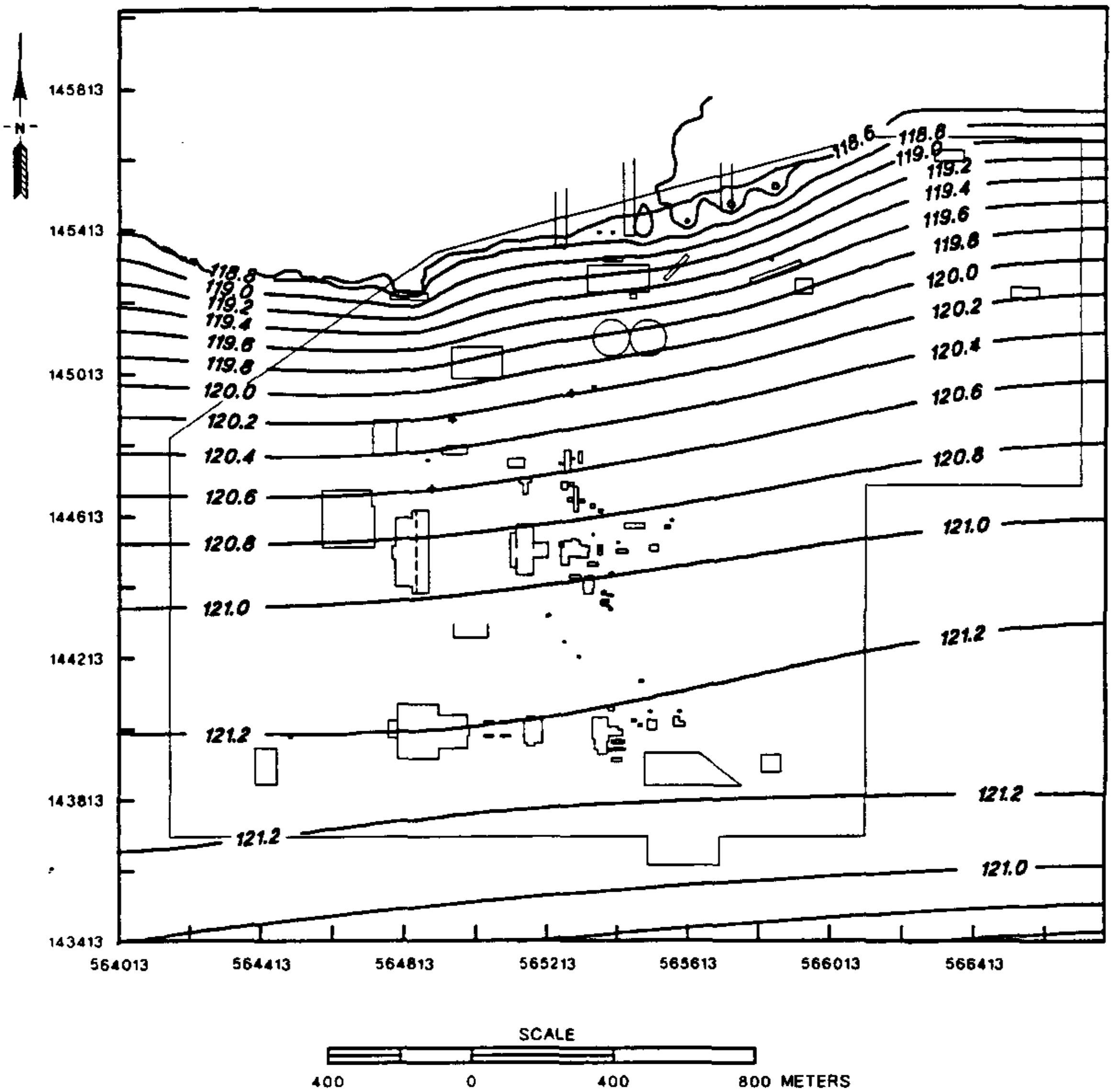


**Figure 5-14 Groundwater Extraction Alternative Water Table Contour Map
15 Year Simulation**



LEGEND

119 WATER LEVEL ELEVATION CONTOUR (m)

6.0 DETAILED ANALYSIS

The ~~detailed analysis for the~~ 100-BC-5 Operable Unit is presented in Tables 6-1 through 6-4. The tables are organized by alternative and by the CERCLA nine criteria. Evaluation of the alternatives against the ARAR is presented in Table 6-5.

Nine evaluation criteria have been identified in EPA guidance to evaluate remedial actions. The evaluation criteria are the basis for the detailed analysis task during the FFS. The evaluation criteria as defined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988) are discussed below.

6.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion provides an assessment of whether each alternative provides adequate protection of human health and the environment. Evaluation focuses on a specific alternative's ability to achieve adequate protection and describes how site risks posed through each pathway being addressed by the FFS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation also allows for consideration of any unacceptable short-term or cross-media impacts associated with each alternative. The following questions represent the information included in the analysis of this criterion:

- Will risk be at acceptable levels?
- What is the time frame to achieve acceptable levels?
- Will additional threats be minimized?

6.2 COMPLIANCE WITH ARAR

This criterion is used to determine whether each alternative will meet Federal and State ARAR and TBC or if there is justification for an ARAR waiver. The CERCLA defines six types of ARAR waivers as follows:

- interim actions
- greater risk to health and the environment
- technical impracticability
- equivalent standard of performance
- inconsistent application of state requirements
- fund-balancing.

Questions concerning compliance with ARAR which are addressed in the detailed analysis include:

- Are ARAR available?
- What are the potential ARAR?

- Will the potential ARAR be met and how?
- What is the basis for waivers?
- If ARAR are not available, what are the potential TBC?
- Is the alternative consistent with the potential TBC?

6.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

This criterion addresses the risk remaining at the site after RAO have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following questions are addressed in the detailed analysis:

- What is the magnitude of the remaining risk?

- What remaining sources of risk can be identified? How much is due to treatment residuals and how much is due to untreated residual contamination?

- Will a 5-year review be required?

- What is the likelihood that the technologies will meet required process efficiencies of performance specifications?

- What type and degree of long-term management is required?

- What are the requirements for long-term monitoring?

- What operation and maintenance functions must be performed?

- What difficulties and uncertainties may be associated with long-term operation and maintenance?

- What is the potential need for replacement of technical components?

- What is the magnitude of the threats or risks should the remedial action need replacement?

- What is the degree of confidence that controls can adequately handle potential problems?

- What are the uncertainties associated with land disposal of residuals and untreated waste?

6.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The goal of this criterion is to address the statutory preference for remedial actions which employ treatment technologies that permanently and significantly reduce toxicity, mobility, and volume. This evaluation focuses on the following questions:

- Does the treatment process employed address the principal threats?
- Are there any special requirements for the treatment process?
- What portion (mass, volume) of contaminated material is destroyed?
- What portion (mass, volume) of contaminated material is treated?
- To what extent is the total mass of toxic contaminants reduced?
- To what extent is the mobility of toxic contaminants reduced?
- To what extent is the volume of toxic contaminants reduced?
- To what extent are the effects of treatment irreversible?
- What residuals remain?
- What are their quantities and characteristics?
- What risks do treatment residuals pose?
- Are principal threats within the scope of the action?
- Is treatment used to reduce inherent hazards posed by principal threats at the site?

6.5 SHORT-TERM EFFECTIVENESS

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until RAO are met. The following factors should be addressed as appropriate for each alternative:

- health and safety of the community during remedial actions
- health and safety of workers during remedial actions
- environmental impacts
- time until remedial response objectives are achieved.

6.6 IMPLEMENTABILITY

The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:

- technical feasibility:
  - construction and operation
  - reliability of technology
  - ease of undertaking additional remedial action
  - monitoring considerations
  - ability of technology to meet PRG, including detection limit

- administrative feasibility - activities needed to coordinate with other offices and agencies

- availability of services and materials:
  - availability of adequate offsite treatment, storage capacity, and disposal services
  - availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources
  - availability of services and materials plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies
  - availability of prospective technologies.

6.7 COST

This criterion addresses capital costs, both direct and indirect, annual operations and maintenance (O&M) costs, accuracy of cost estimate, present worth analysis and cost sensitivity analysis of alternatives.

6.7.1 Direct Capital Costs

Direct capital costs include:

- construction costs
- equipment costs
- land and site-development costs
- building and service costs
- relocation expenses
- disposal costs.

6.7.2 Indirect Capital Costs

Indirect capital costs include:

- engineering expenses
- license or permit costs
- startup and shakedown costs
- contingency allowances.

6.7.3 Annual O&M Costs

Annual O&M costs include:

- operating labor costs
- maintenance materials and labor costs
- auxiliary material and energy
- disposal of residues
- purchased services
- administrative costs
- insurance, taxes, and licensing costs
- maintenance reserve and contingency funds
- rehabilitation costs
- costs of periodic site reviews.

6.7.4 Accuracy of Cost Estimates

Study estimates of costs are expected to provide an accuracy of +50% to -30% and are prepared using data available from the LFI, treatability studies, and ongoing projects.

6.7.5 Present Worth Analysis

Present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year, usually the current year. This allows all alternatives to be assessed based on current costs of the remedial action. The present worth analysis requires assumption to be made regarding the discount rate and the period of performance. A discount rate of 5% before taxes and after inflation is recommended. Period of performance should not exceed 30 years.

6.8 REGULATORY ACCEPTANCE

This criterion evaluates the technical and administrative concerns of the regulating agency. These concerns are generally addressed in the ROD.

6.9 COMMUNITY ACCEPTANCE

This is an evaluation of the concerns of the public and is addressed in the ROD.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 1 of 11)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-1: NO ACTION
Will risk be at acceptable levels?	Human Health: Yes, currently existing conditions present low human health risk (incremental cancer risk 10^{-6} to 10^{-4}, hazard quotient <1) for both the frequent- and occasional-use scenarios, based on the 100-BC-5 Operable Unit Qualitative Risk Assessment (QRA) (WHC 1993c) and supplemental risk assessment (Appendix B). Environment: Uncertain; currently existing conditions present low ecological risk (<1 rad/day, U.S. Department of Energy (DOE) Order 5400.5) from radionuclides, based on the 100-BC-5 Operable Unit QRA (WHC 1993c). Potential risks exist because the concentrations of chromium and aluminum exceed the ambient water quality criteria in the near-river wells. This risk i as determined in the QRA is conservative because no allowance has been made for natural attentuation of the contaminants. No quantification of risk in the substrate has been made.
Timeframe to achieve acceptable levels?	The risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels based on the maximum strontium-90 concentration of 130 pCi/L. While the concentration of strontium-90 is at an acceptable risk level, it is above the current and proposed Safe Drinking Water Act (SDWA) maximum contaminant level (MCL). The time required for the peak concentration of strontium-90 in the near river wells to decay to the 42 pCi/L proposed MCL and the 8 pCi/L current MCL is approximately 49 years and 120 years, respectively. Due to the high adsorption rate and low desorption rate within the unconfined aquifer, the majority of strontium-90 will decay prior to migrating into the Columbia River.
Will additional threats be minimized?	No additional threats will result from the implementation of this alternative.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative

COMPLIANCE WITH ARAR	ALTERNATIVE GW-1: NO ACTION
What are the potential applicable or relevant and appropriate requirements (ARAR)?	See Table 6-5.
Will the potential ARAR be met? How?	See Table 6-5.
Basis for waivers?	Potential basis for ARAR waiver of SDWA MCL based on technical impracticability. The high adsorption and low desorption characteristics of the strontium-90 in the aquifer sediments makes removal of the strontium-90 difficult. Also, ability to treat to MCL is unknown. The Ambient Water Quality Criteria for chromium and aluminum are exceeded in the near-river wells and springs; however, they were below the criteria in the river.
What are the potential to-be-considered (TBC)?	See Table 6-5.
Is the alternative consistent with TBC listed above	See Table 6-5.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 3 of 11)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-1: NO ACTION
What is the magnitude of the remaining risk?	The 100-BC-5 Operable Unit QRA and supplemental risk assessment indicate the current risk to human health and the environment from strontium-90 is low. The currently existing concentrations of strontium-90 in the unconfined aquifer will continue to decrease by radioactive decay.
What remaining sources of risk can be identified?	Based on the current low risk from the 100-BC-5 Operable Unit identified in the QRA and the supplemental risk assessment, no remaining sources of risk can be identified. Based on the high adsorption rate and low desorption rate for strontium-90, the majority of contamination will decay while isolated within the unconfined aquifer.
What is the likelihood that the technologies will meet performance needs?	Remedial technologies are not included in the no action alternative; therefore performance needs are not identified. Although low risk from the 100-BC-5 Operable Unit is identified in the QRA and supplemental risk assessment, monitoring of the site is assumed to continue through the year 2008. Ecological risks are currently uncertain and will be further evaluated through current actions being conducted on site.
What type and degree of long-term management is required?	No long-term management is required for this alternative. Monitoring of the operable unit is conducted under existing programs. Long-term management requirements beyond the IRM period will be addressed by the final remedial action.
What are the requirements for long-term monitoring?	The current monitoring program will continue through the IRM period; evaluations will be made periodically to determine the need for additional remedial action or changes in the monitoring program.
What operation and maintenance (O&M) functions must be performed?	No O&M functions will be required throughout the period of government control to perform and maintain groundwater monitoring activities.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 4 of 11)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-1: NO ACTION
What difficulties may be associated with long-term O&M?	None.
What is the potential need for replacement of technical components?	None.
What is the magnitude of risk should the remedial action need replacement?	No different than current risk.
What is the degree of confidence that controls can adequately handle potential problems?	The number of monitoring wells currently in place is considered adequate to effectively monitor contaminant migration within the 100-BC-5 Operable Unit. The frequency of sampling and the number of samples taken ensure accurate monitoring results.
How is the removed contamination disposed of?	Not applicable. No contaminants are removed from the aquifer (other than for monitoring).

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 5 of 11)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-1: NO ACTION
Does the treatment process address the principal threats?	The no action alternative does not involve treatment. The migration of strontium-90 into the Columbia River presents low risk to human health and the environment, based on the 100-BC-5 Operable Unit QRA (WHC 1993c) and supplemental risk assessment (Appendix B). Ecological risks from chromium and aluminum are uncertain but are likely low.
Are there any special requirements for the treatment process?	No special requirements are associated with this alternative.
What portion of the contaminated material is treated/destroyed?	Contaminated material is neither treated nor destroyed.
To what extent is total mass of toxic contaminants reduced?	The mass of strontium-90 is reduced by radioactive decay. Due to the high adsorption rate and low desorption rate of strontium-90 within the unconfined aquifer, the majority of contamination will decay prior to migration into the Columbia River.
To what extent is the mobility of toxic contaminants reduced?	Contaminant mobility is not reduced; however, the contaminant mobility is relatively low due to the high adsorption and low desorption characteristics of the strontium-90. The velocity of strontium-90 in the unconfined aquifer is significantly less than the velocity of the groundwater itself. Based on the retardation factor used in the groundwater modeling (see Section 4.0), the travel time for strontium-90 to reach the river is 213 times greater than that of the groundwater.
To what extent is the volume of toxic contaminants reduced?	Contaminant volume is not reduced through treatment; however, the strontium-90 will naturally decay.
To what extent are the effects of the treatment irreversible?	Radioactive decay and contaminant migration into the river is irreversible.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-1: NO ACTION
What are the quantities of residuals and characteristics of the residual risks?	No treatment residuals result from this alternative.
What risk do treatment of residuals pose?	No risk from treatment is associated with this alternative.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	The inherent hazards associated with the principal threat of the strontium-90 are low and currently at acceptable levels. Strontium-90 levels are reduced by natural radioactive decay. No treatment is included in this alternative.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 7 of 11)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-1: NO ACTION
What are the risks to the community during remedial actions that must be addressed?	None.
How will the risks to the community be addressed and mitigated?	Not applicable.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers that need to be addressed?	None.
What risks remain to the workers that cannot be readily controlled?	None.
How will the risks to the workers be addressed and mitigated?	None.
What environmental impacts are expected with the construction and implementation of the alternative?	None based on the use of existing monitoring wells.
What are the impacts that cannot be avoided should the alternative be implemented?	None.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 8 of 11)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-1: NO ACTION
How long until remedial action objectives are achieved?	The RAO for protection of human health and the environment are satisfied under the current conditions of the 100-BC-5 Operable Unit, based on the QRA and supplemental risk assessment. Reductions of strontium-90 concentrations in the unconfined aquifer to SDWA MCL will eventually be achieved through radioactive decay. As described previously, the 130 pCi/L peak concentration of strontium-90 will decay to the proposed 42 pCi/L SDWA MCL in approximately 49 years and to the current 8 pCi/L SDWA MCL in approximately 120 years, resulting in even lower risk.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 9 of 11)

IMPLEMENTABILITY	ALTERNATIVE GW-1: NO ACTION
What difficulties and uncertainties are associated with construction?	None.
What is the likelihood that technical problems will lead to schedule delays?	None.
What likely future remedial actions are anticipated?	Based on the currently acceptable risk to human health identified in the 100-BC-5 Operable Unit QRA and supplemental risk assessment, the need for future remedial actions is unlikely. Continuous decay of strontium-90 will further reduce the already acceptable risk associated with the 100-BC-5 Operable Unit. Ecological risks are assumed to be low; however, current activities being conducted at the 100 Area will provide information for additional analysis of ecological risk.
What risks of exposure exist should monitoring be insufficient to detect failure?	Groundwater monitoring failure would not result in exposure risks greater than the currently existing low risk to human health and the environment identified in the 100-BC-5 Operable Unit QRA and supplemental risk assessment.
What activities are proposed which require coordination with other agencies?	None.
Are adequate treatment, storage capacity, and disposal services available?	Treatment, storage, and disposal are not applicable to this alternative.
Are the necessary equipment and specialists available?	Yes, groundwater monitoring is a well established technology.
What additional equipment and specialists are required and what are their potential impacts to implementation?	None.
Are technologies under consideration generally available and sufficiently demonstrated?	Yes, groundwater monitoring is well established technology.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative
(Page 10 of 11)

IMPLEMENTABILITY	ALTERNATIVE GW-1: NO ACTION
Will technologies require further development before they can be applied at the site?	No.
Will more than one vendor be available to provide a competitive bid?	Yes, groundwater monitoring equipment and services are commercially available.

Table 6-1 Detailed Analysis for GW-1, No Action Alternative (Page 11 of 11)

COST COMPONENT	ALTERNATIVE GW-1: NO ACTION
Capital?	$0
Operation and Maintenance?	$0
Present Worth?	$0

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 1 of 11)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
Will risk be at acceptable levels?	Human Health: Yes, currently existing conditions present low human health risk (incremental cancer risk 10^{-6} to 10^{-4}, hazard quotient < 1) for both the frequent- and occasional-use scenarios, based on the 100-BC-5 Operable Unit Qualitative Risk Assessment (QRA) (WHC 1993c) and supplemental risk assessment (Appendix B). Environment: Uncertain; currently existing conditions present low ecological risk (< 1 rad/day, U.S. Department of Energy (DOE) Order 5400.5) from radionuclides, based on the 100-BC-5 Operable Unit QRA (WHC 1993c). Potential risks exist because the concentrations of chromium and aluminum exceed the ambient water quality criteria in the near-river wells. This risk i as determined in the QRA is conservative because no allowance has been made for natural attentuation of the contaminants. No quantification of risk in the substrate has been made.
Timeframe to achieve acceptable levels?	The risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels based on the maximum strontium-90 concentration of 130 pCi/L. While the concentration of strontium-90 is at an acceptable risk level, it is above the current and proposed Safe Drinking Water Act (SDWA) maximum contaminant level (MCL). The time required for the peak concentration of strontium-90 in the near river wells to decay to the 42 pCi/L proposed MCL and the 8 pCi/L current MCL is approximately 49 years and 120 years, respectively. Due to the high adsorption rate and low desorption rate within the unconfined aquifer, the majority of strontium-90 will decay prior to migrating into the Columbia River.
Will additional threats be minimized?	No additional threats will result from the implementation of this alternative.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 2 of 11)

COMPLIANCE WITH ARAR	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What are the potential applicable or relevant and appropriate requirements (ARAR)?	See Table 6-5.
Will the potential ARAR be met? How?	See Table 6-5.
Basis for waivers?	Potential basis for ARAR waiver of SDWA MCL based on technical impracticability. The high adsorption and low desorption characteristics of the strontium-90 in the aquifer sediments makes removal of the strontium-90 difficult. Also, ability to treat to MCL is unknown. The Ambient Water Quality Criteria for chromium and aluminum are exceeded in the near-river wells and springs; however, they were below the criteria in the river.
What are the potential to-be-considered (TBC)?	See Table 6-5.
Is the alternative consistent with TBC listed above?	See Table 6-5.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 3 of 11)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What is the magnitude of the remaining risk?	The 100-BC-5 Operable Unit QRA and supplemental risk assessment indicate the current risk to human health and the environment from strontium-90 is low. This low risk will decrease further as strontium-90 decays. Based on the high adsorption rate and low desorption rate within the unconfined aquifer, the majority of strontium-90 will decay prior to migrating into the Columbia River.
What remaining sources of risk can be identified?	Based on the low risk to human health and the environment associated with the 100-BC-5 Operable Unit identified in the QRA and supplemental risk assessment, no remaining sources of risk can be identified. As noted above, the high adsorption rate and low desorption rate will result in the majority of strontium-90 decaying while isolated in the unconfined aquifer.
What is the likelihood that the technologies will meet performance needs?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, performance needs for the institutional controls alternative are defined as the prevention of access to and contact with contaminated groundwater. Institutional controls (access restrictions, water rights restrictions, groundwater monitoring) are minimum technology actions which require maintenance and enforcement by the responsible authorities. Government control of the Hanford Site is assumed to be maintained through the year 2018, based on the Tri-Party Agreement.
What type and degree of long-term management is required?	Long-term management requirements for this alternative involve continued access restriction enforcement and groundwater monitoring until such time as these actions are considered no longer necessary.
What are the requirements for long-term monitoring?	The current monitoring program will continue and evaluations will be made periodically to determine the need for additional remedial action or changes in the monitoring program.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 4 of 11)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What operation and maintenance (O&M) functions must be performed?	O&M will be required throughout the action period to perform and maintain groundwater monitoring activities and access control.
What difficulties may be associated with long-term O&M?	None foreseeable during government control of the site (through the IRM period). A defined responsible party will be required to perform O&M after government control of the site is terminated.
What is the potential need for replacement of technical components?	Periodic replacement or refurbishing of groundwater monitoring wells may be required on an as needed basis. Technical aspects of access restrictions require only enforcement and upkeep of fences, signs, and barriers.
What is the magnitude of risk should the remedial action need replacement?	Negligible risk is associated with the maintenance or replacement of groundwater monitoring wells. These activities primarily involve physical hazards to workers such as those associated with drilling activities.
What is the degree of confidence that controls can adequately handle potential problems?	The number of monitoring wells currently in place is considered adequate to effectively monitoring contaminant migration within the 100-BC-5 Operable Unit. The frequency of sampling and the number of samples taken ensure accurate monitoring results. Based on the intended recreational use of the 100 Area after the period of government control, no potential problems in restricting access to contaminated groundwater are anticipated.
How is the removed contamination disposed of?	Not applicable. No contaminants are removed from the aquifer (other than for monitoring).

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 5 of 11)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
Does the treatment process address the principal threats?	The institutional controls alternative does not involve treatment. However, the principal threat of strontium-90 migration into the Columbia River presents low risk to human health and the environment, based on the 100-BC-5 Operable Unit QRA (WHC 1993c) and supplemental risk assessment (Appendix B).
Are there any special requirements for the treatment process?	No special requirements are associated with this alternative.
What portion of the contaminated material is treated/destroyed?	Contaminant material is not destroyed through treatment; however, the strontium-90 will radioactively decay naturally.
To what extent is total mass of toxic contaminants reduced?	The mass of strontium-90 is reduced by radioactive decay. Due to the high adsorption rate and low desorption rate of strontium-90 within the unconfined aquifer, the majority of contamination will decay prior to migration into the Columbia River.
To what extent is the mobility of toxic contaminants reduced?	Contaminant mobility is not reduced; however, the mobility of strontium-90 is relatively low. The velocity of strontium-90 in the unconfined aquifer is significantly less than the velocity of the groundwater itself. Based on retardation factor used in the groundwater modeling (see Section 5.0), the travel time for strontium-90 to reach the river is 213 times greater than that of the groundwater.
To what extent is the volume of toxic contaminants reduced?	Contaminant volume is not reduced through treatment but the strontium-90 does decay naturally.
To what extent are the effects of the treatment irreversible?	Radioactive decay and contaminant migration into the river is irreversible.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 6 of 11)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What are the quantities of residuals and characteristics of the residual risks?	No treatment residuals result from this alternative.
What risk do treatment of residuals pose?	No risk from treatment is associated with this alternative.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	The inherent hazards associated with the strontium-90 are low and at acceptable levels. No treatment is included in this alternative.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 7 of 11)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What are the risks to the community during remedial actions that must be addressed?	None.
How will the risks to the community be addressed and mitigated?	Not applicable.
What risks remain to the community that cannot be readily controlled?	None.
What are the risks to the workers that need to be addressed?	Risks to workers are associated with groundwater monitoring. Minimal exposure risks are anticipated with monitoring activities. The exposure duration associated with monitoring is estimated to be approximately 12 hours per year per worker.
What risks remain to the workers that cannot be readily controlled?	None.
How will the risks to the workers be addressed and mitigated?	Workers involved with monitoring activities will be required to undergo extensive training in sample collection and handling procedures. Health and safety protocols will be established and enforced, such as specification of personal protection equipment, safe work practices, contaminant control measures, and decontamination procedures.
What environmental impacts are expected with the construction and implementation of the alternative?	None, based on the use of existing monitoring wells. Negligible impacts are anticipated if periodic well maintenance is required.
What are the impacts that cannot be avoided should the alternative be avoided should the alternative be implemented?	Impacts are minimal.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 8 of 11)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
How long until remedial action objectives are achieved?	The remedial action objectives for protection of human health and the environment are satisfied under the current conditions of the 100-BC-5 Operable Unit, based on the QRA and supplemental risk assessment. Reductions of strontium-90 concentrations in the unconfined aquifer to SDWA MCL will eventually be achieved through radioactive decay. As described previously, the 130 pCi/L peak concentration of strontium-90 will decay to the proposed 42 pCi/L SDWA MCL in approximately 49 years and to the current 8 pCi/L SDWA MCL in approximately 120 years, resulting in even lower risk.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 9 of 11)

IMPLEMENTABILITY	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
What difficulties and uncertainties are associated with construction?	None.
What is the likelihood that technical problems will lead to schedule delays?	None.
What likely future remedial actions are anticipated?	Based on the currently acceptable risk to human health and the environment identified in the 100-BC-5 Operable Unit QRA (WHC 1993c) and supplemental risk assessment, the need for future remedial actions is unlikely. Continuous decay of strontium-90 will further reduce the already acceptable risk associated with the 100-BC-5 Operable Unit.
What risks of exposure exist should monitoring be insufficient to detect failure?	Groundwater monitoring failure would not result in exposure risks greater than the currently existing low risk to human health and the environment identified in the 100-BC-5 Operable Unit QRA (WHC 1993c) and supplemental risk assessment. The risk identified in the risk assessments was determined using the maximum concentration of strontium-90 and should represent a maximum risk under the exposure scenario.
What activities are proposed which require coordination with other agencies?	After the period of government control (year 2018), enforcement of groundwater access restrictions and performance of groundwater monitoring will require coordination with other agencies.
Are adequate treatment, storage capacity, and disposal services available?	Treatment, storage, and disposal are not applicable to this alternative.
Are the necessary equipment and specialists available?	Yes, groundwater monitoring and access restrictions are well established technologies.
What additional equipment and specialists are required and what are their potential impacts to implementation?	None.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 10 of 11)

IMPLEMENTABILITY	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
Are technologies under consideration generally available and sufficiently demonstrated?	Yes, groundwater monitoring and access restrictions are well established technologies.
Will technologies require further development before they can be applied at the site?	No.
Will more than one vendor be available to provide a competitive bid?	Yes, groundwater monitoring equipment and services are commercially available.

Table 6-2 Detailed Analysis for GW-2, Institutional Controls/Continued Current Actions Alternative (Page 11 of 11)

COST COMPONENT	ALTERNATIVE GW-2: INSTITUTIONAL CONTROLS/ CONTINUED CURRENT ACTIONS
Capital?	$0
Operation and Maintenance?	$1,000,000
Present Worth?	$760,000

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 1 of 15)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-3: CONTAINMENT
Will risk be at acceptable levels?	Human Health: Yes, current human health risk is low (incremental cancer risk 10^{-6} to 10^{-4}, hazard quotient <1) for both the frequent- and occasional-use scenarios, based on the 100-BC-5 Operable Unit Qualitative Risk Assessment (QRA) (WHC 1993c) and supplemental risk assessment (Appendix B). Environment: Uncertain; currently existing conditions present low ecological risk (<1 rad/day, U.S. Department of Energy (DOE) Order 5400.5) from radionuclides, based on the 100-BC-5 Operable Unit QRA (WHC 1993c). Potential risks exist because the concentrations of chromium and aluminum exceed the ambient water quality criteria in the near-river wells. This risk as determined in the QRA is conservative because no allowance has been made for natural attentuation of the contaminants. No quantification of risk in the substrate has been made.
Timeframe to achieve acceptable levels?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, the timeframe to achieve the containment of the strontium-90 plume is equivalent to the time required for implementation, i.e., the implementation of the wall immediately prevents chromium behind the wall from reaching the river. However, chromium located between the wall and the river will not be obstructed from reaching the river. Procurement and construction time for installation of the cutoff wall and hydraulic control wells is estimated to be approximately one year. However, the time required to perform the necessary administrative activities, prepare the remedial design, and obtain the necessary permits and agreements to perform construction activities along the river is uncertain.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 2 of 15)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-3: CONTAINMENT
Will additional threats be minimized?	Additional threats to workers resulting from implementation of this alternative will be minimized by developing health and safety protocols defining training requirements, safe work practices, and personal protection equipment, contamination control measures, and decontamination procedures. Additional threats to the environment resulting from implementation of this alternative will be minimized by limiting habitat disturbances to the extent possible and performing construction activities during seasons when threatened or endangered species, such as the bald eagle, do not inhabit the area.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 3 of 15)

COMPLIANCE WITH ARAR	ALTERATIVE GW-3: CONTAINMENT
What are the potential applicable or relevant and appropriate requirements (ARAR)?	See Table 6-5.
Will the potential ARAR be met? How?	See Table 6-5.
Basis for waivers?	Potential basis for ARAR waiver of Safe Drinking Water Act (SDWA) maximum contaminant level (MCL) based on technical impracticability. The high adsorption and low desorption characteristics of the strontium-90 in the aquifer sediments makes removal of the strontium-90 difficult. Also, ability to treat to MCL is unknown.
What are the potential to-be-considered (TBC)?	See Table 6-5.
Is the alternative consistent with TBC listed above	See Table 6-5.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERATIVE GW-3: CONTAINMENT
What is the magnitude of the remaining risk?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, groundwater modeling results indicate this alternative can reduce the flow of contaminated groundwater into the Columbia River by 87% compared to the no action alternative. This reduction was shown for both simulation periods considered, 15 and 25 years. Contaminated groundwater contained by the cutoff wall would not result in increased risk due to limited accessibility. After the period of government control (year 2018) the 100 Area is intended for recreational use. Concentrations of strontium-90 will decrease from radioactive decay during the period of government control and recreational use of the 100 Area. The 130 pCi/L peak concentration of strontium-90 will be reduced to the SDWA MCL of 42 pCi/L (proposed) and 8 pCi/L (current) in approximately 49 years and 120 years, respectively.
What remaining sources of risk can be identified?	The remaining source of risk is the strontium-90 contaminated groundwater contained by the cutoff wall at concentrations above the current 8 pCi/L and proposed 42 pCi/L SDWA MCL. This risk is at acceptable levels. In addition, the contaminated groundwater contained by the cutoff wall would not be readily accessible to the public or the environment.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 5 of 15)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERATIVE GW-3: CONTAINMENT
What is the likelihood that the technologies will meet performance needs?	The risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels. However, the performance need is reduction of strontium-90 entering the river. Groundwater modeling results indicate this alternative can reduce the flow of contaminated groundwater into the Columbia River by 87% compared to the no action alternative. However, the successful installation a cutoff wall at the 100 B/C Area using deep soil mixing is uncertain. Although deep soil mixing is a well developed technology, implementation difficulties due to the 45 m (150 ft) depth requirement and the presence of boulders within the Hanford formation complicate construction of the cutoff wall. Similarly, hydraulic control measures (extraction wells at the ends of the mixed soil wall) enhance the effectiveness of the cutoff wall, but significant fluctuations in the water table elevation near the river may create operational difficulties.
What type and degree of long-term management is required?	Long-term management requirements for this alternative include monitoring and maintenance of the containment system. Groundwater monitoring between the river and the cutoff wall can be used to determine unacceptable leakage from the system. Additional deep soil mixing columns can be installed where leakage is identified. The duration of long-term management requirements may be defined by the SDWA MCL. On this basis, strontium-90 will decay to the proposed 42 pCi/L and current 8 pCi/L MCL in approximately 49 years and 120 years, respectively.
What are the requirements for long-term monitoring?	Groundwater monitoring as well as cutoff wall integrity monitoring will be required to assess the effectiveness of the containment system for as long as containment is required. As described above, the duration of monitoring requirements may be defined on the basis of strontium-90 decay to the concentrations of the SDWA MCL.
What operation and maintenance (O&M) functions must be performed?	Operating requirements are specific to monitoring activities. Maintenance of the monitoring system as well as the components of the containment system will be required on an as needed basis.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERATIVE GW-3: CONTAINMENT
What difficulties may be associated with long-term O&M?	Maintenance requirements to the cutoff wall may involve installation of additional deep soil mixing columns. Similar to the initial installation requirements, boulders within the Hanford formation would pose significant difficulties during maintenance of the wall.
What is the potential need for replacement of technical components?	Assuming proper installation of the cutoff wall, replacement will not likely be required within the timeframe required for strontium-90 concentrations to decay to acceptable levels (SDWA MCL). However, maintenance and repair requirements as described above may be necessary on an as needed basis. Replacement of groundwater monitoring wells and equipment may also be required on an as needed basis.
What is the magnitude of risk should the remedial action need replacement?	The magnitude of risk to workers and the environment during replacement of the cutoff wall would be equivalent to the risk during initial installation. The risk to workers from exposure to the contaminant is greatly reduced by the use of deep soil mixing techniques. Migration of the strontium-90 plume during replacement will likely result in minimal contamination release to the river.
What is the degree of confidence that controls can adequately handle potential problems?	Groundwater monitoring down-gradient from the wall can effectively determine potential problems associated with the containment system. Maintenance or repair of the cutoff wall would be difficult and involves installation of additional deep soil mixing columns.
How is the removed contamination disposed of?	During normal operations no contaminated materials will be generated other than samples from monitoring activities. The technologies specified for construction of the containment system result in minimal contact with contamination. The pre-excavation for removal of boulders from the Hanford formation is assumed to be conducted within uncontaminated soils. Deep soil mixing will result in minimal contamination of equipment. Installation of the hydraulic control wells will also result in minimal contamination of equipment. Sonic drilling may be used to reduce the generation of cuttings requiring disposal. Contaminated materials generated as a result of construction, monitoring, or standard operations will be disposed at the Environmental Restoration Disposal Facility (ERDF), W-025, or another site will be used if ERDF if unavailable.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERATIVE GW-3: CONTAINMENT
Does the treatment process address the principal threats?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, groundwater modeling results indicate the containment alternative can reduce the flow rate of strontium-90 contaminated groundwater entering the Columbia River up to 87% compared to the baseline (no action).
Are there any special requirements for the treatment process?	The effectiveness of the cutoff wall requires key-in to a confining geologic formation (aquitard) below the unconfined aquifer. This requires construction of the cutoff to a depth of approximately 45 m (150 ft) below the surface. In addition, removal of boulders within the Hanford formation is required prior to initiation of deep soil mixing.
What portion of the contaminated material is treated/destroyed?	The purpose of this alternative is containment, and therefore contamination is neither treated nor destroyed. However, the strontium-90 will naturally radioactively decay.
To what extent is total mass of toxic contaminants reduced?	Containment of the contaminant plume enables strontium-90 to decay without continued migration into the Columbia River. However, due to the high adsorption rate and low desorption rate of strontium-90 within the unconfined aquifer, the majority of contamination would decay prior to migration into the Columbia River regardless of any containment measures implemented.
To what extent is the mobility of toxic contaminants reduced?	The mobility of the strontium-90 plume is significantly reduced by the containment alternative. The hydraulic conductivity of the cutoff wall (10^{-6} to 10^{-7} cm/sec) would be several orders of magnitude less than the hydraulic conductivity of the unconfined aquifer near the river (10^{-2} to 10^{-3} cm/sec). Based on an assumed hydraulic conductivity of 10^{-6} cm/sec hydraulic conductivity for the cutoff wall, groundwater modeling results indicate an 87% reduction in the flow rate of contaminated groundwater into the river during the IRM period. Based on the retardation factor used in the groundwater modeling (see Section 5.0), the unrestricted velocity of strontium-90 in the unconfined aquifer is 213 times less than that of the groundwater.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 8 of 15)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERATIVE GW-3: CONTAINMENT
To what extent is the volume of toxic contaminants reduced?	The volume of contamination is not reduced by containment. However, radioactive decay during the period in which containment is maintained reduces the concentration of strontium-90 in the groundwater. The half-life of strontium-90 is approximately 30 years.
To what extent are the effects of the treatment irreversible?	Isolation of strontium-90 contaminated groundwater by installation of a cutoff wall and hydraulic control wells is not irreversible. Isolation is temporary and dependent on maintaining the integrity of the containment system. Decay of the strontium-90 during the period in which containment is maintained is irreversible.
What are the quantities of residuals and characteristics of the residual risks?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, the contaminated groundwater isolated by the containment system represents the residual risk associated with this alternative. Radioactive decay will continually reduce the concentration of strontium-90 and the corresponding risk.
What risk do treatment of residuals pose?	Contaminated groundwater contained by the cutoff wall will not be treated but is allowed to attenuate by radioactive decay.
Is treatment used to reduce inherent hazards posed by principal threats at the site?	This alternative does not involve treatment. However, the inherent hazards associated with strontium-90 are reduced by radioactive decay.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 9 of 15)

SHORT-TERM EFFECTIVENESS	ALTERATIVE GW-3: CONTAINMENT
What are the risks to the community during remedial actions that must be addressed?	Construction of the cutoff wall will pose minimal risk to the surrounding communities. Due to the remote location of the 100-BC-5 Area, construction activities are not expected to impact the surrounding community. The deep soil mixing technique chosen for implementation of the cutoff wall will result in minimal contact with contamination in the unconfined aquifer. The pre-excavation (to remove boulders) is assumed to be conducted within noncontaminated soil.
How will the risks to the community be addressed and mitigated?	Minimal risks to the community result from implementation of this alternative. Dust control measures would be used as required to prevent airborne spread of contamination.
What risks remain to the community that cannot be readily controlled?	Potential risks to humans through contact with spring water with elevated chromium concentrations.
What are the risks to the workers that need to be addressed?	Since minimal contact contamination will result during implementation of this alternative, physical hazards relating to construction activities presents the primary risk to workers. These physical hazards are associated with machinery operations, handling and placement of field tools, and vehicle operations. Additional risks may be associated with field work, such as slip, trip, fall, and heat stress. Although the deep soil mixing tool will require decontamination after operation within the unconfined aquifer, contaminated soil will not be brought to the surface. The containment alternative has the greatest potential for impacts to the worker. Use of heavy equipment and the physical size of the project result in a medium to high worker risk from physical hazards. Exposure risks are expected to be low.
What risks remain to the workers that cannot be readily controlled?	None.
How will the risks to the workers be addressed and mitigated?	Health risks to workers resulting from physical hazards associated with construction activities will be minimized by development of health and safety protocols defining training requirements, safe work practices, and personal protection equipment.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 10 of 15)

SHORT-TERM EFFECTIVENESS	ALTERATIVE GW-3: CONTAINMENT
What environmental impacts are expected with the construction and implementation of the alternative?	The environmental impacts associated with construction and implementation of this alternative are primarily physical disturbances to habitat in the area of the 450 m (1,500 ft) long cutoff wall. The pre-excavation will require space for slurry preparation, material storage (bentonite, barite, water), spoils storage, and backfill preparation (removal of cobbles and boulders from excavated spoils). No additional disturbances will result from deep soil mixing operations. Although the 100 B/C Area is a previously disturbed site, installation of the cutoff wall may result in temporary impacts to endangered species such as the bald eagle. However, construction during seasonal times when such species are not inhabiting the area will minimize potential impacts. The barrier would be located in a potential wetland/floodplain zone. Assessment of impacts would be required prior to implementation. Other threatened and endangered species would need to be identified in the proposed zone of construction. Impact would be minimized by proper placement design. Environmental and cultural surveys required prior to implementation.
What are the impacts that cannot be avoided should the alternative be implemented?	Environmental impacts resulting from construction of the cutoff wall cannot be avoided. Physical disturbances to habitat will be temporary and limited to the general area of the cutoff wall, which is approximately 450 m (1,500 ft) along the Columbia River. No significant impacts such as disturbances to threatened or endangered species are anticipated.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 11 of 15)

SHORT-TERM EFFECTIVENESS	ALTERATIVE GW-3: CONTAINMENT
How long until remedial action objectives are achieved?	The remedial action objectives for protection of human health and the environment are satisfied under the current conditions of the 100-BC-5 Operable Unit, based on the QRA and supplemental risk assessment. However, this alternative may significantly reduce the volume of strontium-90 contaminated groundwater entering the Columbia River. This reduction will be achieved upon installation of the cutoff wall and operation of the hydraulic control wells for the zone behind the wall. However, contamination between the wall and the river will continue to migrate to the river. As noted previously, procurement and installation of this containment system is estimated to require approximately one year. However, the time required to obtain the required permits and agreements to begin construction is unknown.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative
(Page 12 of 15)

IMPLEMENTABILITY	ALTERATIVE GW-3: CONTAINMENT
What difficulties and uncertainties are associated with construction?	The two primary concerns associated with construction of the cutoff wall are subsurface obstructions (the presence of boulders in the Hanford formation) and the cutoff wall depth requirement. A pre-excavation is proposed to remove boulders from the Hanford formation prior to implementation of deep soil mixing. The Hanford formation comprises the vadose zone in the vicinity of the proposed location of the cutoff wall, and therefore contact with contamination from the unconfined aquifer is not required. However, slurry trench excavation is proposed for this activity as opposed to conventional excavation, due to the physical constraints imposed by the proximity of the Columbia River and past practice disposal sites (retention basins, trenches, cribs). The trench developed during the pre-excavation can be backfilled using the original soils removed (without boulders) such that deep soil mixing can be performed. The required depth of the cutoff wall is approximately 45 m (150 ft). This depth is beyond the conventional use of deep soil mixing. However, equipment vendors suggest the depth required at the 100-BC-5 Operable Unit is feasible. Treatability testing may be required.
What is the likelihood that technical problems will lead to schedule delays?	Deep soil mixing techniques are well established. However, technical problems associated with subsurface obstructions (boulders) or installation to the required 45 m (150 ft) depth could lead to schedule delays. In the event these technical problems cannot be overcome, the cutoff wall may not be implementable. Treatability testing of the proposed technique can demonstrate the applicability of the method and identify possible technical problems that may be encountered. The treatability testing would aid in remedial design also.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative

IMPLEMENTABILITY	ALTERATIVE GW-3: CONTAINMENT
What likely future remedial actions are anticipated?	Assuming the cutoff wall can be successfully implemented, no future remedial actions are likely. Radioactive decay of strontium-90 will eventually eliminate concern of groundwater contamination at 100-BC-5. As noted previously, the peak concentration of strontium-90 will decay to the proposed 42 pCi/L and current 8 pCi/L SDWA MCL in approximately 49 years and 120 years, respectively. These include pump and treat, innovative in situ technologies, or other alternatives. Current activities are bieng directed at defining true risks to the river and the future need for remedial actions.
What risks of exposure exist should monitoring be insufficient to detect failure?	The inability to detect failure of the containment system would result in the continued strontium-90 release into the river. However, based on the 100-BC-5 Operable Unit QRA (WHC 1993c) and supplemental risk assessment, present conditions do not pose significant risk to human health or the environment. Therefore, failure of the containment system would not be expected to result in additional risk to that currently existing.
What activities are proposed which require coordination with other agencies?	None foreseeable. However, due to the proximity of the proposed cutoff wall and the Columbia River, other agencies such as the U.S. Army Corps of Engineers, the Washington State Department of Fish and Wildlife, and the National Park Service may be involved during design and construction.
Are adequate treatment, storage capacity, and disposal services available?	Containment does not involve contact with contamination, and therefore does not require treatment, storage, and disposal services. In the event contaminated material is generated as a result of construction activities or decontamination requirements, it would be disposed at ERDF.
Are the necessary equipment and specialists available?	Yes, slurry excavation and deep soil mixing construction equipment and specialists are commercially available. All other equipment and specialists required are available with the Hanford Site contractors.
What additional equipment and specialists are required and what are their potential impacts to implementation?	Slurry excavation and deep soil mixing specialists and equipment are required to ensure proper installation of the cutoff wall.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative (Page 14 of 15)

IMPLEMENTABILITY	ALTERATIVE GW-3: CONTAINMENT
Are technologies under consideration generally available and sufficiently demonstrated?	Yes, slurry excavation and deep soil mixing techniques are available and sufficiently demonstrated.
Will technologies require further development before they can be applied at the site?	The proposed cutoff wall installation technique should be tested. A treatability test can demonstrate the applicability of the method as well as identify potential technical problems that may be encountered during construction in the 100 B/C Area.
Will more than one vendor be available to provide a competitive bid?	Yes, slurry excavation and deep soil mixing technology is commercially available.

Table 6-3 Detailed Analysis of GW-3, Containment Alternative (Page 15 of 15)

COST COMPONENT	ALTERATIVE GW-3: CONTAINMENT
Capital?	$8,000,000
Operation and Maintenance?	$12,900,000
Present Worth?	$17,500,000

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 1 of 20)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
Will risk be at acceptable levels?	<u>Human Health:</u> Yes, currently existing conditions present low human health risk (incremental cancer risk 10^{-6} to 10^{-4}, hazard quotient < 1) for both the frequent- and occasional-use scenarios, based on the 100-BC-5 Operable Unit Qualitative Risk Assessment (QRA) (WHC 1993c) and the supplemental risk assessment. <u>Environment:</u> Uncertain; currently existing conditions present low ecological risk (<1 rad/day, U.S. Department of Energy (DOE) Order 5400.5) from radionuclides, based on the 100-BC-5 Operable Unit QRA (WHC 1993c). Potential risks exist because the concentrations of chromium and aluminum exceed the ambient water quality criteria in the near-river wells. This risk i as determined in the QRA is conservative because no allowance has been made for natural attentuation of the contaminants. No quantification of risk in the substrate has been made.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 2 of 20)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
Timeframe to achieve acceptable levels?	Although the risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels, the 130 pCi/L peak concentration of strontium-90 is above the current and proposed Safe Drinking Water Act (SDWA) maximum contaminant level (MCL). Groundwater modeling results indicate pump-and-treat can reduce the flow of contaminated groundwater into the Columbia River, but not the concentration of strontium-90 in the unconfined aquifer. During the periods simulated by groundwater modeling (15 and 25 years), reductions in the concentration of strontium-90 calculated for the pump-and-treat alternatives are equivalent to the no action alternative. This result suggests the high adsorption and low desorption rates of strontium-90 inhibit the effectiveness of pump-and-treat to the point that natural radioactive decay has the most significant effect on reductions in the concentration of strontium-90 in the unconfined aquifer. Therefore, the timeframe to achieve the SDWA MCL is the same as no action.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 3 of 20)

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
Will additional threats be minimized?	Additional threats posed by strontium-90 removed from groundwater will be minimized by treatment and disposal. Settling tank sludge and precipitation residues will be solidified using cement and then disposed at Environmental Restoration Disposal Facility (ERDF), W-025, or another site. Ion exchange resin will be dewatered followed by disposal at ERDF.	Additional threats posed by strontium-90 removed from groundwater will be minimized by treatment and disposal. Settling tank sludge and evaporator concentrates will be solidified using cement and then disposed at ERDF, W-025, or another site.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 4 of 20)

COMPLIANCE WITH ARAR	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What are the potential applicable or relevant and appropriate requirements (ARAR)?	See Table 6-5.	Same as Alternative GW-5.
Will the potential ARAR be met? How?	See Table 6-5.	Same as Alternative GW-5.
Basis for waivers?	Potential basis for ARAR waiver of SDWA MCL based on technical impracticability. The high adsorption and low desorption characteristics of the strontium-90 in the aquifer sediments makes removal of the strontium-90 difficult. Also, ability to treat to MCL is unknown. The Ambient Water Quality Criteria for chromium and aluminum are exceeded in the near-river wells and springs; however, they were below the criteria in the river.	Same as Alternative GW-5.
What are the potential to-be-considered (TBC)?	See Table 6-5.	Same as Alternative GW-5.
Is the alternative consistent with TBC listed above	See Table 6-5.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 5 of 20)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What is the magnitude of the remaining risk?	The risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels. However, pump-and-treat will further reduce the risk from the 100-BC-5 Operable Unit by lowering the concentration of strontium-90 to the SDWA MCL, 8 pCi/L (current) or 42 pCi/L (proposed).	Same as Alternative GW-5.
What remaining sources of risk can be identified?	The secondary wastes generated from the treatment system are the remaining sources of risk. The primary sources of secondary wastes generated by the treatment process include settling tank sludge, precipitation residues, and spent ion exchange resins. Based on cement solidification of these wastes followed by disposal at ERDF, the risk from secondary wastes is considered minimal. Cement based solidification is well developed and has been successfully demonstrated on the types of secondary waste generated by this alternative.	Same as Alternative GW-5, except that the primary sources of secondary wastes generated by the treatment process include settling tank sludge, permeate from the reverse osmosis system, and filter cartridges.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 6 of 20)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What is the likelihood that the technologies will meet performance needs?	The ability of the treatment system to reduce strontium-90 concentrations to the current or proposed SDWA MCL (8 pCi/L and 42 pCi/L, respectively) is uncertain. Results of the EQ3/6 computer model indicate lime precipitation is highly effective and can reduce the 130 pCi/L peak concentration in the groundwater to below the current MCL. However, full-scale operation of a 400 gpm precipitation system may not achieve the same effectiveness. Ion exchange has been demonstrated to effectively remove high concentrations of strontium-90 from groundwater (Robinson et al. 1993), but not to SDWA MCL levels.	The ability of reverse osmosis to reduce strontium-90 concentrations to the current or proposed SDWA MCL (8 pCi/L and 42 pCi/L, respectively) is uncertain. Reverse osmosis has been demonstrated to effectively remove high concentrations of strontium-90 from groundwater (Garrett 1990), but not to SDWA MCL levels.
What type and degree of long-term management is required?	Long-term management is required only through the duration of the treatment period to operate and maintain the removal, treatment, and disposal systems, satisfy annual reporting requirements, and perform periodic groundwater monitoring. Based on groundwater modeling results, the duration of management required is equivalent to the time required for strontium-90 to decay to the SDWA MCL. Once treatment is no longer necessary, no additional management will be required at the site.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 7 of 20)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What are the requirements for long-term monitoring?	The current groundwater monitoring program will continue through the duration of government control of the site (year 2018). Beyond year 2018 (if necessary), long-term monitoring requirements and responsibilities will be determined by Washington State Department of Ecology, U.S. Environmental Protection Agency (EPA), and DOE.	Same as Alternative GW-5.
What operation and maintenance (O&M) functions must be performed?	O&M functions are required only during the IRM period to ensure continuous treatment and monitoring. Once pump-and-treat is no longer necessary (compliance with SDWA MCL for strontium-90), O&M functions will be no longer required.	Same as Alternative GW-5.
What difficulties may be associated with long-term O&M?	None foreseeable.	Same as Alternative GW-5.
What is the potential need for replacement of technical components?	Periodic replacement of treatment system components (e.g., mixing tank, rotary drum filter, ion exchange columns), materials (e.g., lime, sulfuric acid, ion exchange resin), extraction wells, monitoring wells, and associated ancillary equipment (e.g., pumps, piping) will be required on an as needed basis.	Periodic replacement of treatment system components (reverse osmosis vessels, high pressure pump, evaporation heater), materials (membranes), extraction wells, monitoring wells, and associated ancillary equipment (pumps, piping) will be required.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 8 of 20)

LONG-TERM EFFECTIVENESS AND PERMANENCE	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What is the magnitude of risk should the remedial action need replacement?	The risk to human health and the environment from the 100-BC-5 Operable Unit is currently at acceptable levels. However, in the event treatment is unavailable for extended periods, untreated contaminated groundwater could enter the river. The concentrations and risk associated with this groundwater would be at lower levels than at present because of radioactive decay and because risk is based on maximum concentrations.	Same as Alternative GW-5.
What is the degree of confidence that controls can adequately handle potential problems?	Potential problems associated with operation of the treatment system include equipment failure, leaks or spills, and contaminant removal inefficiency. Control measures can adequately protect human health and the environment should such problems arise. The treatment system will be equipped with automated shut-down controls, secondary containment measures, and effluent concentration monitoring.	Same as Alternative GW-5.
How is the removed contamination disposed of?	Spent ion exchange resins will be disposed following dewatering. Other treatment residuals such as settling tank sludge, solids from the regeneration loop, and filtered precipitates will be solidified in cement. All treatment residuals will be disposed on the Hanford Site at ERDF, W-025, or another site.	Contaminants removed by the reverse osmosis system will be evaporated to form a concentrate stream that can then be solidified with cement. Solidified evaporator concentrates (and other secondary wastes) will be disposed on the Hanford Site at ERDF, W-025, or another site.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 9 of 20)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
Does the treatment process address the principal threats?	Yes. Groundwater modeling results indicate the extraction system can reduce the flow rate of strontium-90 contaminated groundwater into the Columbia River by 92% compared to the baseline (no action). In addition, the precipitation and ion exchange processes have been shown to be effective treatment techniques for removal of strontium-90 from groundwater. Due to the high adsorption rate for strontium-90, removal from the aquifer may be difficult.	Same as Alternative GW-5, except that reverse osmosis has been shown to be an effective treatment technology for removal of strontium-90 from groundwater.
Are there any special requirements for the treatment process?	Process monitoring and control capabilities are essential to the effectiveness of the treatment system. Control of the lime addition is essential to maximize precipitation of the strontianite. The EQ3/6 model indicates the pH must be maintained between 10.3 and 10.4 to minimize the solubility of strontianite. The ion exchange process will require the pH of the precipitation process effluent to be reduced by addition of a reducing reagent such as sulfuric acid. The ion exchange process will also require a filtration pretreatment to remove suspended solids that may be present in the effluent from the precipitation process. Such suspended solids could result in plugging or fouling of the ion exchange columns. Monitoring strontium-90 concentrations, pH, and other constituents (such as sulfate added in the form of sulfuric acid) in the treatment system effluent is required to ensure acceptable levels prior to disposal.	Process monitoring and control capabilities are essential to the effectiveness of the treatment system. Pretreatment such as pH adjustment and a crystallization inhibitor will be required to maximize effectiveness of the reverse osmosis process. The evaporation process is required to minimize the volume of secondary waste generated.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 10 of 20)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What portion of the contaminated material is treated/destroyed?	The majority of contamination is adsorbed onto the formation comprising the unconfined aquifer, due to the high adsorption rate associated with strontium-90. Based on comparisons between the groundwater modeling results obtained for the pump-and-treat alternatives and no action, radioactive decay has the most significant effect on the reduction of strontium-90 concentrations in the groundwater. Therefore, the portion of contaminated material treated is difficult to define. However, the groundwater modeling results do indicate the pump-and-treat alternatives can reduce the flow rate of contaminated groundwater into the Columbia River by 92% compared to the baseline.	Same as Alternative GW-5.
To what extent is total mass of toxic contaminants reduced?	Groundwater modeling indicates the pump-and-treat alternatives can reduce the flow rate of contaminated groundwater entering the Columbia River by approximately 92% compared to the baseline (no action). The capability of the treatment system to reduce the concentration of strontium-90 to the SDWA MCL is uncertain and will require treatability studies to verify. However, due to the high adsorption rate of strontium-90 within the unconfined aquifer, radioactive decay is the primary effect on contaminant concentration reduction in the groundwater.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 11 of 20)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
To what extent is the mobility of toxic contaminants reduced?	Groundwater modeling results indicate the flow rate of strontium-90 contaminated groundwater into the Columbia River is reduced by 92% compared to the baseline (no action). The mobility of strontium-90 removed from the groundwater by treatment is minimized by subsequent disposal at ERDF. Liquid-type secondary wastes generated during treatment are solidified in cement prior to disposal at ERDF. Based on retardation factor used in the groundwater modeling (see Section 5.0), the travel time for strontium-90 to reach the river is 213 times greater than that of the groundwater.	Same as Alternative GW-5.
To what extent is the volume of toxic contaminants reduced?	Based on the high adsorption rate associated with strontium-90 in the unconfined aquifer, the volume of contaminated groundwater is not significantly reduced by pump-and-treat. As contaminated groundwater is removed from the aquifer, desorption of strontium-90 into previously uncontaminated groundwater occurs. The rate of extraction is not sufficient to remediate the aquifer prior to the natural radioactive decay of strontium-90.	Same as Alternative GW-5.
To what extent are the effects of the treatment irreversible?	Removal of strontium-90 by chemical precipitation, ion exchange, and solidification is considered irreversible.	Removal of strontium-90 by reverse osmosis, evaporation, and solidification is considered irreversible.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 12 of 20)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
What are the quantities of residuals and characteristics of the residual risks?	Spent ion exchange resin will be generated when breakthrough is detected in the ion exchange system. Preliminary estimates indicate that 180 cu ft of spent resin and 5,733 cu ft of resing regeneration solids will be produced each year of operation. The volume of spent ion exchange resin generated will be dependent on the treatment system design and strontium-90 concentration in the feed stream. The EQ3/6 model predicted 33 pounds of precipitant is generated per hour, based on the 400 gpm extraction rate. The volume of precipitant formed is dependent on the concentration of strontium-90 in the feed stream. Solidification in cement is assumed to result in a 2 to 1 volume increase. Treatability studies will be required to determine precise quantities of treatment residuals generated.	Reverse osmosis will reduce the volume of strontium-90 contaminated groundwater by approximately 5 to 1 (Garrett 1993). The evaporator will result in additional volume reductions based on approximately 50% solids concentration. Concentrate from the evaporator will be solidified in cement which will result in a volume increase of approximately 2 to 1. Treatability studies will be required to determine precise volumes of treatment residuals generated.
What risks do treatment of residuals pose?	All secondary waste generated will be classified as low level waste (LLW). Spent resins will be dewatered and then disposed without additional treatment. Cement solidification of liquid-type, radioactive waste forms (such as precipitation residues and settling tank sludge and resin regeneration solids) is well developed. The risk from treatment of secondary waste is therefore considered minimal.	All secondary waste generated will be classified as LLW. Solid waste such as filter cartridges will be disposed without additional treatment. Cement solidification of liquid-type, radioactive waste forms (such as evaporator concentrates and settling tank sludge) is well developed. The risk from treatment of secondary waste is therefore considered minimal.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 13 of 20)

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME	ALTERNATIVE GW-5 Ion Exchange/Precipitation Treatment	ALTERNATIVE GW-6 Reverse Osmosis Treatment
Is treatment used to reduce inherent hazards posed by principal threats at the site?	Yes. strontium-90 removal from 100-BC-5 groundwater will reduce the threat posed by strontium-90 migration into the river. Treatment residuals will pose minimal risk to human health and the environment based on disposal at an approved facility. Although solid-type secondary waste forms may be disposed without additional treatment, cement solidification will be used for liquid-type treatment residuals.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 14 of 20)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
What are the risks to the community during remedial actions that must be addressed?	None.	Same as Alternative GW-5.
How will the risks to the community be addressed and mitigated?	Not applicable.	Same as Alternative GW-5.
What risks remain to the community that cannot be readily controlled?	None.	Same as Alternative GW-5.
What are the risks to the workers that need to be addressed?	Risks to workers are associated with handling treatment residuals, operation and maintenance of treatment process equipment, and groundwater monitoring. The risks to workers associated with groundwater extraction and handling is considered to be low.	Same as Alternative GW-5.
What risks remain to the workers that cannot be readily controlled?	None.	Same as Alternative GW-5.
How will the risks to the workers be addressed and mitigated?	Standard operating procedures will be establish to define proper treatment system operating parameters and maintenance requirements. Health and safety plans will establish training requirements, identify personal protection equipment needs, specify treatment residual handling procedures, and define general safe work practices.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 15 of 20)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
What environmental impacts are expected with the construction and implementation of the alternative?	The primary impact to the environment from construction and implementation of the pump-and-treat alternatives will be physical disturbances of habitat near the Columbia River which may potentially be inhabited by threatened or endangered species (such as the bald eagle). Construction and installation of the treatment system, extraction wells, and associated plumbing will be limited to an area approximate 450 m (1,500 ft) in length along the river. The proposed location of the extraction wells and treatment system will be within previously disturbed locations of the 100 B/C Area.	Same as Alternative GW-5.
What are the impacts that cannot be avoided should the alternative be implemented?	Physical disturbances to habitat resulting from construction and implementation are unavoidable. However, environmental impacts can be minimized by prefabricating components of the pump-and-treat system to the extent possible. In addition, construction activities can be conducted during seasonal times when endangered species such as the bald eagle are not present in the area.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 16 of 20)

SHORT-TERM EFFECTIVENESS	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
How long until remedial action objectives are achieved?	The remedial action objective for protection of human health and the environment are satisfied under the current conditions of the 100-BC-5 Operable Unit, based on the QRA (WHC 1993c) and supplemental risk assessment. The time required to reduce the flow rate of contaminated groundwater into the Columbia River is equivalent to the time required for start-up of the pump-and-treat system. The time required to achieve aquifer restoration by pump-and-treat is based on the established cleanup levels and desorption kinetics of strontium-90 from the aquifer formation into the groundwater. Groundwater modeling results indicate that radioactive decay has a more significant effect on the reduction of strontium-90 concentrations in the unconfined aquifer than does pump-and-treat. On the basis of radioactive decay, the 130 pCi/g peak concentration of strontium-90 in the unconfined aquifer will be reduced to the SDWA MCL of 8 pCi/L (current) and 42 pCi/L (proposed) after approximately 120 years or 49 years, respectively.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 17 of 20)

IMPLEMENTABILITY	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
What difficulties and uncertainties are associated with construction?	None. Construction of extraction wells and precipitation/ion exchange treatment systems is well developed technology.	Same as Alternative GW-5.
What is the likelihood that technical problems will lead to schedule delays?	Since chemical precipitation, ion exchange, and groundwater extraction are well developed technologies, technical problems are not likely to cause schedule delays. However, failure of the pump-and-treat system to achieve performance objectives (effluent strontium-90 concentrations) could result in schedule delays.	Since reverse osmosis, evaporation, and groundwater extraction are well developed technologies, technical problems are not likely to cause schedule delays. However, failure of the pump-and-treat system to achieve performance objectives (effluent strontium-90 concentrations) could result in schedule delays.
What likely future remedial actions are anticipated?	Once aquifer restoration is achieved, no additional remedial actions will be necessary.	Same as Alternative GW-5.
What risks of exposure exist should monitoring be insufficient to detect failure?	Monitoring failure could lead to prematurely ending treatment operations. The resulting risk would depend on the extent of treatment up to that point in time. This risk could be no greater than the baseline conditions identified in the limited field investigation QRA.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 18 of 20)

IMPLEMENTABILITY	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
What activities are proposed which require coordination with other agencies?	Discharge of treated groundwater into the Columbia river or reinjection into the aquifer will require coordination with other agencies such as U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology, U.S. Army Corps of Engineers, National Parks Department, and the Washington State Department of Fish and Wildlife.	Same as Alternative GW-5.
Are adequate treatment, storage capacity, and disposal services available?	Chemical precipitation and ion exchange technologies are commercially available. Disposal services will be available within the Hanford Site at ERDF.	Reverse osmosis and evaporation technologies are commercially available. Disposal services will be available within the Hanford Site at ERDF.
Are the necessary equipment and specialists available?	Yes. Chemical precipitation and ion exchange technology and specialists are available within the DOE and private industry.	Yes. Reverse osmosis and evaporation technology and specialists are available within the DOE and private industry.
What additional equipment and specialists are required and what are their potential impacts to implementation?	None.	Same as Alternative GW-5.
Are technologies under consideration generally available and sufficiently demonstrated?	Yes. Chemical precipitation and ion exchange are well developed technologies that have been used extensively for treatment of liquid radioactive wastes. Groundwater extraction and monitoring are also established technologies.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 19 of 20)

IMPLEMENTABILITY	ALTERNATIVE GW-5 Removal, Treatment, Disposal	ALTERNATIVE GW-6
Will technologies require further development before they can be applied at the site?	Results of the EQ3/6 model indicate precipitation of strontium-90 by lime addition is highly effective. However, treatability testing is required to demonstrate full-scale operation. Ion exchange has been shown to effectively reduce high concentrations of strontium-90 in groundwater (Robinson et al. 1993). However, treatability tests are required to demonstrate effectiveness for the low concentrations of strontium-90 present in 100-BC-5 groundwater.	Reverse Osmosis has been shown to effectively reduce high concentrations of strontium-90 in the groundwater (Garrett 1990). However, treatability tests will be required to demonstrate effectiveness for the low concentrations existing in 100-BC-5 groundwater.
Will more than one vendor be available to provide a competitive bid?	Yes.	Same as Alternative GW-5.

Table 6-4 Detailed Analysis of GW-5 and GW-6, Removal, Treatment, and Disposal Alternatives (Page 20 of 20)

COST COMPONENT	ALTERNATIVE GW-5	ALTERNATIVE GW-6
Capital?	$1,850,000	$4,900,000
Operation and Maintenance?	$12,500,000	$25,300,000
Present Worth?	$11,100,000	$23,600,000

Table 6-5 Compliance with ARAR and TBC (Page 1 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
40 CFR 191.03	All	<25 mrem whole body; <75 mrem critical organ	Limited exposure; personal protective equipment; health and safety training and monitoring
10 CFR 21.101-105	All	Sets radiation doses, levels, and concentrations	Limited exposure; personal protective equipment; health and safety training and monitoring
40 CFR 141	GW-3, GW-5, GW-6	Strontium-90 - 8 pCi/L	Discharges after treatment will likely meet the ARAR (some uncertainty exists); concentrations at near river wells will remain above ARAR for lifecycle of IRM; however, mixing of the groundwater with the river will limit impacts
40 CFR 122	GW-3, GW-5, GW-6	Sets discharge limits to surface waters	No treated water will be discharge to the river which exceeds drinking water standards or ambient water quality criteria
40 CFR 110	GW-3, GW-5, GW-6	Prohibits discharge of oil above water quality standards or that causes a sheen on water surface	Runoff control will be implemented during all activities. All tanks will be bermed.
40 CFR 144	GW-3, GW-5, GW-6	Prohibits injections that allows movement of contaminated fluid into underground sources of drinking water if they would violate 40 CFR 142 or adversely affect human health	No current use of groundwater as residential drinking water. Treatment will likely meet drinking water standards for all constituents except tritium; currently, no feasible treatments exist for tritium so there is a basis for ARAR waiver under technical impracticability.
40 CFR 146	GW-3, GW-5, GW-6	Establishes siting, construction, operating, monitoring, and closure requirements for injection wells	All injection wells will be in compliance with requirements.

Table 6-5 Compliance with ARAR and TBC (Page 2 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
40 CFR 261	GW-3, GW-5, GW-6	Chromium is a hazardous waste	Chromium will be treated as a hazardous waste.
40 CFR 262.34	GW-3, GW-5, GW-6	Allows accumulation of hazardous waste for 90 days or less without a permit	Wastes will not be stored on site longer than 90 days.
40 CFR 268	GW-3, GW-5, GW-6	Prohibits placement of RCRA wastes in landfill unless treated.	All solid wastes will be treated prior to disposal
40 CFR 50.12	GW-3, GW-5, GW-6	$\leq$50 $\mu g/m^3$ annual average concentration of particulate emissions or 150 $\mu g/m^3$ per 24-hr period	Excavation and drilling activities will use dust control measures as required. No other particulate emissions are anticipated from the treatment systems.
16 U.S.C. 469	GW-3, GW-5, GW-6	Requires recovery or preservation of artifacts	Two archaeological sites and an artifact were identified in the 100 B/C Area. Consideration of these sites would be given in placing a vertical barrier in this area. Additional testing of these sites may be required. Impacts from extraction wells could be minimized by proper placement.
50 CFR 17, 222, 225, 226, 227, 402, 424	GW-3, GW-5, GW-6	Actions must not threaten the continued existence of a listed species or destroy critical habitat	Fish and Wildlife Service will be consulted prior to actions
16 U.S.C. 461	All	Requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts must be mitigated.	See 16 U.S.C. 469

Table 6-5 Compliance with ARAR and TBC (Page 3 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
16 U.S.C. 470 et seq.	All	Prohibits impacts and requires mitigation for unavoidable impacts on cultural resources	See 16 U.S.C 469
40 CFR 257.3-1	GW-3, GW-5, GW-6	Prohibits facilities or practices from restricting flow of base flood, reducing temporary storage capacity of floodplain, or causing washout of solid waste	Vertical barrier may have some impact on local ground and surface water flow. However, the wall is relatively short and should not impact the base flood. Other alternatives do not significantly impact floodplain.
40 CFR 257.3-2	GW-3, GW-5, GW-6	Prohibits facilities or practices from causing or contributing to the taking of endangered or threatened species	Activities will be scheduled to avoid impacts to eagles. Runoff control will be employed to prevent construction contaminants from impacting river biota; minimal impacts would be attributable to the pump and treat alternative; the vertical barrier would disturb an area near the river for implementation. This area would be restored after implementation.
16 U.S.C. 1271	All	Prohibits federal agencies from recommending authorization of water resource projects that would have a direct and adverse affect on the qualities of the wild and scenic river	Impacts from the pumping system would be minimal. The vertical barrier would present a short duration impact to visual resources; however, after implementation the site would be restored to provide the visual aesthetics
WAC 173-201A-030	GW-3, GW-5, GW-6	Sets limits for temperature and pH for surface waters	No temperature impacts are associated with the alternatives. No waters with unacceptable pH will be discharged to the river

Table 6-5 Compliance with ARAR and TBC (Page 4 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
WAC 173-201A-040	GW-3, GW-5, GW-6	Chromium - 11 µg/L chronic	Not met in the near river wells during the IRM; currently met in the river. The substrate has not been characterized so it is uncertain whether the criteria are met for this zone
WAC 246-221-010	All	18.75 rem/quarter for hands, wrists, ankles, and feet and 7.5 rem/quarter for skin	Only dealing with low levels of radioactive contaminants, use of personal protective equipment, personnel monitoring, and health and safety plan and training
WAC 232-12-292	All	Requires protection of bald eagle habitat	All activities will be scheduled to avoid impacts to the eagles during nesting; remedial actions will not result in destruction of eagle nesting habitat.
WAC 232-12-297	All	Prescribes actions to protect wildlife defined as endangered or threatened	Activities will be scheduled to avoid impacts to eagles. Runoff control will be employed to prevent construction contaminants from impacting river biota; minimal impacts would be attributable to the pump and treat alternative; the vertical barrier would disturb an area near the river for implementation. This area would be restored after implementation.
WAC 173-400-040	GW-3, GW-5, GW-6	Requires reasonable precautions to minimize fugitive dust emissions; requires good practices to control odors	Dust control measures will be used as required; odors should not be a problem for the proposed alternatives.
WAC 173-340-400	All	Ensures that cleanup actions are performed in accordance with cleanup plan	Regulatory agencies have input into feasibility studies and proposed plans

Table 6-5 Compliance with ARAR and TBC (Page 5 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
WAC 173-340-440	All	Requires physical measures to limit interference with cleanup	Fences and signs will be installed around active remedial projects
RCW 90.44	GW-3, GW-5, GW-6	Sets requirements for withdrawal of state groundwater	Requirements will be met for extraction wells
WAC 173-304-200	GW-3, GW-5, GW-6	Sets requirements for containers and vehicles to be used on site to store or transport solid waste	Any solid waste generated on site as a result of remedial action will be handled according to requirements
WAC 173-218	GW-3, GW-5, GW-6	Establishes permitting requirements for injection wells	Injection wells will be constructed and operated in accordance with substantive requirements of the regulation
WAC 173-160	GW-3, GW-5, GW-6	Establishes minimum standards for wells	All wells will be installed, operated, and closed according to requirements
TBC			
Benton-Franklin-Walla Walla Counties Air Pollution Control Authority General Regulation 80-7, Section 400-040	GW-3, GW-5, GW-6	Not more than 3 min/hr when emissions exceed 20% opacity	Limited potential for emissions, dust control will be provided when necessary
Section 400-060	GW-3, GW-5, GW-6	Prohibits emissions > 0.10 grain per ft^3	
40 CFR 141 (proposed at 56 FR July 18, 1991)	All	Proposed MCL for radionuclides (pCi/L): strontium-90 - 42	Radionuclide contaminant are which are removed through pumping can be removed with IX or RO

Table 6-5 Compliance with ARAR and TBC (Page 6 of 6)

ARAR	ALTERNATIVE AFFECTED	REQUIREMENT	HOW ARE REQUIREMENTS MET?
DOE 5400.5	All	Limits effective dose to 100 mrem/yr. Derived concentration guides for radionuclides in water are (): strontium-90 - 1.0E+03	Radionuclide concentrations are below these levels.
10 CFR 1022	GW-3, GW-5, GW-6	Requires federal agencies to avoid adverse effects associated with development of floodplains	Only temporary effects associated with vertical barrier installation. The wall will be below land surface; land above the wall altered during installation can be restored.
Executive Order 11593	All	Provides direction to federal agencies to preserve, restore, and maintain cultural resources	Several sites may be impacted by implementation of vertical barrier. Impacts can be minimized by careful selection of barrier location and consultation with archaeologists prior to and during installation.
P.L. 100-605	All	Requires minimization of direct and adverse effects on the values for which a river is under study.	Impacts from barrier installation will be relatively short term; disturbed areas can be restored after installation.

ARAR = applicable or relevant and appropriate requirements
IRM = interim remedial measure
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
ERDF = Environmental Restoration Disposal Facility
CAMU = corrective action management unit
RCRA = Resource Conservation and Recovery Act

7.0 QUALITATIVE SENSITIVITY ANALYSIS

The sensitivities associated with the key assumptions for the FFS are presented qualitatively in Table 7-1. This table identifies each key assumption and the impacts that the assumption has on the direction of the FFS and on the associated costs. Additional discussions on uncertainties and sensitivities is included in Section 4.0 and in Appendix C. The details of the cost assumptions used in defining alternative costs are included in the detailed cost model printouts in Appendix E.

Table 7-1 Qualitative Sensitivity Analysis of Key Assumptions (Page 1 of 3)

ASSUMPTION	IMPACT
The purpose of the IRM is to address an identified threat to human health or the environment	The LFI recommended that the operable unit remain on the IRM pathway based on the QRA ecological risk estimation. The ecological risk assessment used concentrations in the near-river wells to determine the EHQ. This resulted in very conservative estimate of risks. If the ecological risk is sufficiently overestimated then the need for remedial action may be artificial. If the risk estimation is underestimated, then additional RAO may be required along with corresponding changes in alternative design. The overestimation of risk results in overexpenditure for potentially unnecessary remedial actions. This overexpenditure would be equivalent to the cost of the remedial action selected for implementation.
The objectives the FFS are to protect the Columbia River and to abate offsite migration of contaminants.	The costs developed in the FFS are based on this assumption. If the objectives were to clean up the aquifer and reduce the mass of contaminant then the remedial systems would have to be redesigned or potentially eliminated in the case of the vertical barrier. The barrier does not perform well in the long term with a persistent mobile contaminant. The wall will hold up the contaminants in the short term, but the contamination will eventually travel around the wall to the river. If mass reduction is the objective, then the well number, placement, and pumping rates would have to be adjusted to meet the objective. The costs for pump and treat are mainly influenced by well installation costs and pumping rate. The mass reduction scenario would likely require more wells than currently proposed and increased pumping rates. This scenario would probably result in significant increases to both the pump and treat options.

Table 7-1 Qualitative Sensitivity Analysis of Key Assumptions (Page 2 of 3)

To meet the objectives, the alternatives are aimed at containment and control of contaminant plumes. (The alternatives are not designed for mass reduction or aquifer cleanup.)	The same sensitivities apply to this assumption as to the previous assumption.
The occasional-use scenario is assumed for the operable unit.	This assumption does not include drinking water wells. The frequent-use scenario does include drinking water wells and would have an effect on RAO and objectives for the IRM. The frequent-use scenario results in the identification of additional COC for human health. The treatment processes for the pump and treat scenarios would have to be modified to address these additional COC and the objectives of the IRM would be modified to include both protection of the river and mass reduction. Alternate water supplies could be considered. The technical practicability of achieving these RAO through pump and treat is uncertain. Additional testing may be required to determine aquifer response and surface treatment. The cost of the alternatives would increase somewhat to account for system changes. Additional costs would be incurred determining aquifer response and for system modification to address RAO.
The lifecycle for the FFS is assumed to be to 2008	The present worth calculations are tied to this timeframe. The capital costs, O&M costs, and present worths for each year can be seen on the present worth tables presented in Appendix E. Costs associated with years past 2008 can be extrapolated from the tables.

Table 7-1 Qualitative Sensitivity Analysis of Key Assumptions (Page 3 of 3)

The *100 Area Feasibility Study Phases 1 & 2* (DOE-RL 1994a) forms the basis for the alternatives evaluated in the FFS. Additional alternatives or deviations from the alternatives are only considered when the defined alternative does not meet the operable unit specifics. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) does, however, allow the flexibility of specifying different process options at any point in the remedial investigation/feasibility study process if warranted by site circumstances.	The sensitivities to this assumption are small because most of the emerging technologies are not yet implementable in field applications. Research and development activities are proceeding and could lead to significant cost savings to the remedial actions if these innovative technologies become field ready. The technologies can be integrated into the IRM program as data and new techniques become available.
ERDF has sufficient space for operable unit waste and is available to meet schedule	The disposal costs for the pump and treat options tend to be major cost drivers. The disposal cost used in the FFS is $70/yd^3. At the current stage of design for the ERDF, this cost is still uncertain. To provide an estimate of the sensitivity of this cost, $700/yd^3 and $7,000/yd^3 were input into the cost models. Based on analysis of disposal costs associated with an ion exchange or reverse osmosis system (400 gpm), at $700/yd^3, disposal costs increase by +14% resulting in an increase in total project cost of +1%. At a disposal cost of $7000/yd^3, disposal costs increase by +126% resulting in an increase in total project cost of +6%. The total project costs for the vertical barrier are not significantly affected by disposal costs. The cost drivers for the barrier are the length and width of the wall. Uncertainties in hydrogeologic parameters are reflected in the vertical barrier alternative.

8.0 COMPARATIVE ANALYSIS

The comparative analysis evaluates the relative effectiveness of the alternatives for each of the CERCLA criteria. The comparative analysis is summarized in Figure 8-1 and discussed in the following sections.

8.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Results of the 100-BC-5 Operable Unit QRA indicate that strontium-90 presents low risk to human health (ICR 10^{-6} to 10^{-4}, HQ < 1) and the environment (< 1 rad/day, DOE Order 5400.5), based on currently existing conditions (DOE-RL 1993b). Therefore, long-term (after the period of remedial action) protection of human health and the environment can be achieved by each alternative. Although strontium-90 is a low risk to human health and the environment, the primary MCL for strontium-90 and ecological ARAR for chromium and aluminum are exceeded in the near-river wells. Short-term (during the period of remedial action) protection of human health and the environment is dependent on the risks associated with implementation of each alternative. The no action and institutional controls alternatives only involve contact with or exposure to strontium-90 contaminated groundwater during monitoring and sampling activities, whereas, the containment alternative requires intrusion into the contaminant plume and the pump-and-treat alternatives requires management of secondary waste generated during treatment.

Groundwater concentrations are currently within the 10^{-4} risk level for radionuclides. Groundwater modeling results indicate that radioactive decay has the most significant effect on reducing the concentration of strontium-90 in the groundwater to the current 8 pCi/L or proposed 42 pCi/L SDWA MCL, regardless of the remedial action implemented. However, groundwater modeling results also indicate the containment alternative and the pump-and-treat alternatives reduce the flow rate of contaminated groundwater into the Columbia River, compared to the baseline (no action) thereby limiting the strontium-90 being transported to the river in the groundwater.

8.2 COMPLIANCE WITH ARAR

None of the alternatives can currently satisfy the SDWA MCL in the unconfined aquifer, based on the current 8 pCi/L for strontium-90; however, through natural radioactive decay, the concentration in the aquifer will eventually reach the MCL. Although the MCL is currently under review and may be changed to a proposed level of 42 pCi/L, the alternatives would still be unable to achieve the concentration in the unconfined aquifer in the short term. Groundwater modeling results show that the adsorption and desorption characteristics of strontium-90 sufficiently retards the movement of this contaminant in the unconfined aquifer to the point radioactive decay may be the only feasible means of reducing the concentration. Therefore, an ARAR waiver can be formed on the basis of technical impracticability of strontium-90 removal from the unconfined aquifer. The regulation is generally applicable to drinking water sources; because the 100-BC-5 groundwater discharges to the Columbia

River, a drinking water source, the regulation can be considered relevant and appropriate, especially for potential receptors at the springs and seeps. It should be noted, however, that the MCL is based on residential use. The concentration of strontium-90 in the river is below the MCL.

The chronic Ambient Water Quality Criteria for chromium is 11 μg/L; the chronic criteria for aluminum is 146.7 μg/L. Both these criteria are slightly exceeded in the operable unit in both the springs and the near-river wells. The ecological risk determined in the QRA did not account for mixing or dilution of contaminants prior to reaching the receptor. This may have resulted in an overestimation of the real risk. Additional activities currently underway in the 100 Area will provide information to better determine risk to ecological receptors.

8.3 LONG-TERM EFFECTIVENESS

Long-term effectiveness for protection of human health and the environment is ensured by each alternative, based on the low risk currently associated with the 100-BC-5 Operable Unit. Groundwater modeling results show that the containment and pump-and-treat alternatives can provide additional protection by reduction in the flow rate of contaminated groundwater into the Columbia River by 87% and 92%, respectively, compared to the baseline (no action). However, groundwater modeling results also show that the concentration of strontium-90 in the unconfined aquifer is not affected by the remedial action alternatives.

Any migration of the contaminant plume due to natural groundwater flow or pump-and-treat results in continuous desorption from the saturated soils, thereby maintaining an equilibrium concentration of strontium-90 in the groundwater and the soil. The adsorption and desorption characteristics of strontium-90 in the unconfined aquifer prevent effective strontium-90 concentration reduction by application of the remedial action alternatives. The only reduction in strontium-90 concentration within the aquifer are a result of radioactive decay. Based on the relatively short half-life of strontium-90 (approximately 30 years), the long-term risk from the 100-BC-5 Operable Unit will be continuously reduced over time.

8.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

While mobility of strontium-90 is low, groundwater modeling results indicate that the containment and pump-and-treat alternatives can reduce the mobility of strontium-90 by preventing the flow of contaminated groundwater into the Columbia River. Compared to the baseline (no action), the containment and pump-and-treat alternatives reduce the flow of contaminated groundwater into the river by approximately 87% and 92%, respectively. The no action and institutional controls alternatives have no effect on the flow of contaminated groundwater into the river.

For all the alternatives considered, the concentration will reduce over time due to natural radioactive decay. This result would be expected for the containment alternative;

however, lower concentrations beyond the reduction from decay would be anticipated with the no action and institutional controls alternatives due to plume migration into the Columbia River. The pump-and-treat alternatives would be expected to result in the lowest concentrations of strontium-90 because some of the strontium-90 is removed from the aquifer system. A significant result shown by groundwater modeling is the effect of each alternative on the concentration of strontium-90 in the unconfined aquifer. During the simulation periods investigated (15 and 25 years), no distinction between alternatives could be identified on the basis of strontium-90 concentrations in the groundwater.

This result illustrates the effects of the high adsorption rate associated with strontium-90 in the unconfined aquifer. The high adsorption rate of strontium-90 onto the aquifer soils corresponds to a low desorption rate into the groundwater, which retards the transport of strontium-90 within the aquifer. Values of the adsorption coefficient for strontium-90 in the unconfined aquifer vary from 20 to 200 ml/mg (Ames and Serne 1991). Adsorption coefficient values have been reported up to 400 ml/mg for strontium-90 in the Ringold Formation (EPA 1978).

An adsorption coefficient of 20 ml/mg was used for groundwater modeling, based on the conservative assumption that this value would maximize the concentration of strontium-90 in groundwater migrating into the Columbia River. However, use of this value does not represent a conservative assumption when considering the effectiveness of pump-and-treat for aquifer restoration. Therefore, the groundwater modeling results obtained for the pump-and-treat alternatives represent the highest possible effectiveness. Although the lowest adsorption coefficient value was used in groundwater modeling, the results obtained for the pump-and-treat alternatives show the reduction in strontium-90 concentrations is almost entirely due to radioactive decay.

8.5 SHORT-TERM EFFECTIVENESS

The evaluation of short-term effectiveness is based on protection of human health and the environment during construction and implementation of the alternative until RAO are achieved. Based on the remote location of the 100 B/C Area, no impacts to the surrounding communities would result from implementation of the alternatives under consideration. The no action and institutional controls alternatives do not involve contact with or exposure to strontium-90 contaminated groundwater or soil, and therefore present the least risk to workers. Physical hazards are the primary risks to workers during implementation of the containment alternative, which requires excavation in the vadose zone (assumed not contaminated) followed by deep soil mixing into the contaminant plume. The pump-and-treat alternatives subject workers to health risks during O&M of the treatment system in which low level waste is generated and managed.

The containment alternative is considered to involve the most severe environmental impacts during implementation. Spacial requirements to perform the slurry excavation and deep soil mixing will result in significant physical disturbances to habitat along the proposed location of the cutoff wall. Installation of the extraction wells is the primary source of environmental impact from the pump-and-treat alternatives, as prefabrication of the treatment system and pipelines can minimize environmental impacts from these activities. The no action and institutional controls alternatives result in the least impact to the environment due to the nonintrusive nature of these alternatives.

The RAO are basically met for all the alternatives. The time required to achieve additional benefits of an alternative is dependent on the specific alternative. The containment and pump-and-treat alternatives achieve added protection of the Columbia River once construction and implementation is complete. Each alternative requires the same time to satisfy the SDWA MCL for strontium-90. Regardless of the alternative, groundwater modeling results indicate natural radioactive decay is the most significant factor effecting the concentration of strontium-90 in the unconfined aquifer. Therefore, the time required to reduce the 130 pCi/L peak concentration to the current 8 pCi/L, or proposed 42 pCi/L, SDWA MCL is approximately 120 years or 49 years, respectively.

8.6 IMPLEMENTABILITY

The no action and institutional controls alternatives are considered easily implementable. Due to the limited actions involved with these alternatives, there are no technical, administrative, or availability concerns.

Technically, the containment alternative is the most difficult to implement. A pre-excavation is required to remove boulders from the Hanford formation in order to facilitate the use of deep soil mixing. Due to the physical constraints on the surface (e.g., retention basins, cribs, trenches), the proposed pre-excavation utilizes slurry excavation techniques such that near vertical side slopes can be obtained. Once the pre-excavation trench is backfilled, deep soil mixing to a depth of approximately 45 m (150 ft) is required. The approximate 45 m (150 ft) depth is near the technical limitations of conventional deep soil mixing equipment. No other implementability concerns (administrative or availability of services) are associated with this alternative.

The pump-and-treat alternatives will also be technically difficult to implement due to the SDWA MCL target remedial level for strontium-90 (currently 8 pCi/L, but proposed at 42 pCi/L). Ion exchange and reverse osmosis have been demonstrated to effectively remove high concentrations of strontium-90 from groundwater (Robinson et al. 1993, Garrett 1990). However, treatability tests will be required to demonstrate the effectiveness of these technologies for reducing strontium-90 concentrations to 8 pCi/L. No other implementability concerns (administrative or availability of services) regarding this alternative are identified.

8.7 COST

Costs for the alternatives are compared in Table 8-1. Additional details and assumptions for the costs are presented in Appendix C. The costs developed for this FFS cover only those for the implementation and operation of the IRM. Consideration of final action costs are outside the scope of the FFS; however, some general statements are provided for consideration as follows:

- Costs for continuation of the IRM as a final action can be extrapolated from the FFS costs.

- Costs for combining alternatives (such as a vertical barrier in conjunction with pump and treat) can be assumed to be additive (on an order of magnitude basis).

Figure 8-1 Summary of Comparative Analysis

Evaluation Criteria	100-BC-5 Groundwater Operable Unit				
	Alternatives[1]				
	GW-1	GW-2	GW-3	GW-5	GW-6
Overall Protection of Human Health and Environment	●	●	◕	◕	◕
Compliance with ARAR[2]	◔	◔	◔	◔	◔
Long-Term Effectiveness and Permanence	◑	◑	◕	●	●
Reduction of Toxicity, Mobility, and Volume	◑	◑	◕	●	●
Short-Term Effectiveness	●	●	◔	◑	◑
Implementability	●	●	○	◑	◔
Present Worth ($ millions)	0	2.5	16.6	88.7	81.0

Notes:

1. Alternatives are summarized as follows:
   - GW-1 No Interim Action
   - GW-2 Institutional Control
   - GW-3 Containment
   - GW-5 Removal/Ion Exchange Treatment/Disposal
   - GW-6 Removal/Reverse Osmosis Treatment/Disposal
2. ARAR - applicable or relevant and appropriate requirement

Note: GW-4 (In Situ Treatment) was not evaluated.

Key:
- ● Best
- ◕ Better
- ◑ Good
- ◔ Fair
- ○ Poor

E940829.6b

Table 8-1 Cost Comparison of Alternatives

Alternative	Cost		
	Capital	Operation and Maintenance	Present Worth (1)
GW-1 No Action	$ 0	$ 0	$ 0
GW-2 Institutional Controls/Continued Current Actions	$ 0	$ 1,000,000	$ 760,000
GW-3 Containment	$ 8,000,000	$ 12,900,000	$ 17,500,000
GW-4 In Situ Treatment	N/A	N/A	N/A
GW-5 Pump and Treat (with Ion Exchange)	$ 1,850,000	$ 12,500,000	$ 11,100,000
GW-6 Pump and Treat (with Reverse Osmosis)	$ 4,900,000	$ 25,300,000	$ 23,600,000

(1) Based on a discount rate of 5%

9.0 REFERENCES

Ames, L.L. and R.J. Serne, 1991, *Compilation of Data to Estimate Groundwater Migration Potential for Constituents in Active Liquid Discharges at the Hanford Site*, PNL-7660, Pacific Northwest Laboratory, Richland, Washington.

Bechtold, R.A., 1992, *Data Validation Procedures for Chemical Analyses*, WHC-SD-EN-SPP-002, Westinghouse Hanford Company, Richland, Washington.

Bisping, L.E. and R.K. Woodruff, 1992, *Hanford Site Environmental Data for Calendar Year 1992*, PNL-8683, Pacific Northwest Laboratory, Richland, Washington.

Bowles, J.E., 1988, *Foundation Analysis and Design*, Fourth Edition, McGraw-Hill Publishing Company, New York, New York.

Brouns, T.M., S.S. Koegler, J.K. Fredrickson, S.P. Luttrell, and K.A. Borgeson, 1991, *On-Site Bioreclamation, Processes for Zenobiotic and Hydrocarbon Treatment*, Butterworth-Heinemann, Stoneham, Massachusetts.

Caldwell, L.L., 1994, *Wildlife Studies on the Hanford Site: 1993 Highlights Report*, PNL-7380, Pacific Northwest Laboratory, Richland, Washington.

Campbell, M.D., 1994, *Monitoring Groundwater and River Interaction Along the Hanford Reach of the Columbia River*, PNL-9437, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J.C., 1989, *Hanford Cultural Resources Management Plan*, PNL-6942, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J.C., H.A Gard, and P.E. Minthorn, 1992, *Fiscal Year 1991 Report on Archaeological Surveys of the 100 Areas, Hanford Site, Washington*, PNL-8143, UC-600, Pacific Northwest Laboratory, Richland, Washington.

Corbitt, R.A., 1990, *Standard Handbook of Environmental Engineering*, McGraw-Hill Publishing Company, New York, New York.

DOE, 1988, *Low-Level Radioactive Waste Volume Reduction and Stabilization Technologies Resource Manual*, U.S. Department of Energy, Idaho Operations Office, Boise, Idaho.

DOE-RL 1991a, *Hanford Past-Practice Strategy*, DOE/RL-91-40, Draft A, U.S. Department of Energy, Washington, D.C.

DOE-RL 1991b, *Description of Codes and Models to be Used in Risk Assessment*, DOE/RL-91-44, U.S. Department of Energy, Richland, Washington.

DOE-RL 1992a, *Remedial Investigation/Feasibility Study Work Plan for the 100-FR-3 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-91-53, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992b, *Remedial Investigation/Feasibility Study Work Plan for the 100-KR-4 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-90-21, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992c, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit*, DOE/RL-88-36, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992d, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-5 Operable Unit, Hanford Site, Richland, Washington*, DOE/RL-90-08, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992e, *Hanford Site Groundwater Background*, DOE/RL-92-23, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992f, *100-HR-3 Groundwater Treatability Test Plan*, DOE/RL-92-73, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1992g, *Treatability Study Program Plan*, DOE/RL-92-48, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993a, *Columbia River Impact Evaluation Plan*, Rev. 0, DOE/RL-92-28, U.S. Department of Energy, Richland, Washington.

DOE-RL 1993b, *Limited Field Investigation Report for the 100-BC-5 Operable Unit*, DOE/RL-93-37, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1994a, *100 Area Feasibility Study Phases 1 and 2*, Rev. 0, DOE/RL-92-11, U.S. Department of Energy, Richland Operations Office, Richland Washington.

DOE-RL 1994b, *Pilot-Scale Treatability Test Plan for the 100-HR-3 Operable Unit*, Decisional Draft, DOE/RL-94-54, U.S. Department of Energy, Richland, Washington.

DOE-RL 1994c, *Hanford Site Risk Assessment Methodology*, DOE/RL-91-45, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1994d, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*, DOE/RL-93-99, Decisional Draft, U.S. Department of Energy, Richland, Washington.

Driscoll, F.G., 1986, *Groundwater and Wells*, 2nd edition, Johnson Division, St. Paul, Minnesota.

Ebra, M.A., J.P. Bibler, B.S. Johnnston, L.L. Kilpatrick, F.L. Poy, R.M. Wallace and E.I. du Pont de Nemours and Company, 1987, *New Treatment Facility for Low Level Process Effluents at the Savannah River Site*, Savannah River Laboratory, Aiken, South Carolina.

Ecology, EPA and DOE/RL, 1990, *Hanford Federal Facility Agreement and Consent Order*, Washington State Department of Ecology, Olympia, Washington, U.S. Environmental Protection Agency, Region X, Seattle, Washington, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order, Change Order Control Form M-15-93-02*, Washington State Department of Ecology, Olympia, Washington, U.S. Environmental Protection Agency, Region X, Seattle, Washington, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1978, *Radionuclide Interactions with Soil and Rock Media, Volume 1: Processes Influencing Radionuclide Mobility and Retention, Element Chemistry and Geochemistry, Conclusions and Evaluations*, PB 292460, U.S. Environmental Protection Agency, Office of Radiation Programs, Las Vegas, Nevada.

EPA, 1986, *Quality Criteria for Water 1986*, U.S. Environmental Protection Agency, Office of Water Regulation and Standards, EPA/44015/86-001, Washington D.C.

EPA, 1987 *A Compendium of Technologies Used in the Treatment of Hazardous Wastes*, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, Interim Final, OSWER Directive 9355.3-01, EPA/540/G-89/004, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1989, *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual*, Part A, Interim Final, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1991, *Risk Assessment Guidance for Superfund - Volume I Human Health Evaluation Manual*, Part B, Review Draft, U.S. Environmental Protection Agency, Washington D.C.

EPA, 1993, *perox-pure™ Chemical Oxidation Technology Peroxidation Systems, Inc.*, U.S. Environmental Protection Agency, Washington DC.

Eslinger, P.W., L.R. Huesties, A.D. Maughan, T.B. Miley, and W.H. Walters, 1994, *Data Compendium for the Columbia River Comprehensive Impact Assessment*, PNL-9785, UC-630, Pacific Northwest Laboratory, Richland, Washington.

Fitzner, R. E. (Pacific Northwest Laboratory), and S. G. Weiss (Westinghouse Hanford Company), 1994, *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington,* WHC-EP-0510, Rev. 1, Westinghouse Hanford Company, Richland, Washington

Fitzner, R. E. (Pacific Northwest Laboratory), S. G. Weiss and J.A. Stegen (Westinghouse Hanford Company), 1994, *Biological Assessment for Threatened and Endangered Species,* WHC-EP-0513, Rev. 1, Westinghouse Hanford Company, Richland, Washington

Freeman, H.M., 1989, *Standard Handbook of Hazardous Waste Treatment and Disposal,* McGraw-Hill Book Company, New York, New York.

Garrett, L., 1990, *Reverse Osmosis Applications to Low-Level Radioactive Waste,* WHC-SA-0993-FP, Westinghouse Hanford Company, Richland, Washington.

Gee, G.W., 1987, *Recharge at the Hanford Site: Status Report,* PNL-6403, Pacific Northwest Laboratories, Richland Washington.

Geraghty and Miller, Inc, 1993, *Computer Aided Design Software for Groundwater Modeling,* Model Cad386tm, Version No. 2.14, Serial No. 538.

Golden Software, 1991, *Surfer®,* Version 4, Serial No. 28609.

Hartman, M.J. and R.E. Peterson, 1992, *Hydrologic Information Summary for the Northern Hanford Site,* WHC-SD-EN-TI-023, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Hazardous Waste Consultant, 1993, *Advances in Air Sparging Design*, January/February 1993, pp. 1.1-1.10.

HFSUWG, 1992, *Future for Hanford: Uses and Cleanup*, DOE/RL-92-93, Hanford Future Site Uses Working Group, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Konikow, L.F. and J.D. Bredehoeft, 1978, *Computer Model of Two-Dimensional Solute Transport and Dispersion in Groundwater,* U.S. Geological Survey Water Resource Investigations, Book 7, Chapter C2, 90 pp.

Landeen, D.S., M.R. Sackschewsky, and S.G. Weiss, 1993, *100 Areas CERCLA Ecological Investigations* WHC-EP-0620, Westinghouse Hanford Company, Richland, Washington.

Ledgerwood, R.K., 1991, *Summaries of Well Construction Data Field Observations for Existing 100 Aggregate Area Operable Unit Resource Protection Wells*, WHC-SD-ER-TI-006, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lindberg, J.W., 1993, *Geology of the 100-B/C Area, Hanford Site, South-Central Washington*, WHC-SD-EN-TI-133, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

McDonald, J.M. and A.W. Harbaugh, 1988, *Modular Three-Dimensional Finite-Difference Groundwater Flow Model,* MODFLOW, Techniques of Water Resources Investigations of the U.S. Geological Survey, Book 6, 586 pp.

McMahon, W.J. and R.E. Peterson, 1992, *Estimating Aquifer Hydraulic Properties Using the Ferris Method, Hanford Site, Washington*, DOE/RL-92-64, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Moghissi, A.A., H.W. Godbee, and S.A. Hobart, 1986, *Radioactive Waste Technology*, American Society of Mechanical Engineers, The, U.S.A.

Nonveiller, E., 1989, *Grouting Theory and Practice*, Elsevier Science Publishers, Amsterdam, The Netherlands.

PE, 1993, *Moving Beyond Pump-and-Treat,* Pollution Engineering, March 1993.

Peterson, R.E. and V.G. Johnson, 1992, *Riverbank Seepage of Groundwater Along the Hanford Reach of the Columbia River, Washington*, WHC-EP-0609, Westinghouse Hanford Company, Richland, Washington.

Peyton, B.M., 1994, *100 Area Groundwater Biodentrification Bench-Scale Treatability Study -- Final Report*, WHC-SD-EN-ES-043, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Peyton, B.M. and K.R. Martin, 1993, *100 Area Groundwater Biodenitrification Bench-Scale Treatability Study Procedures*, PNL-8610, Pacific Northwest Laboratory, Richland, Washington.

Porter, M.C., 1990, *Handbook of Industrial Membrane Technology*, Noyes Publications, Mill Road, New Jersey.

Reese, J.S., 1992, *Cleaning Water With Low Profile Strippers*, IT Corporation, Ocala, Florida.

Roberts, J.W., 1992, *Description of Work for the 100-BC-5 Groundwater Operable Unit*, WHC-SD-EN-AP-070, Westinghouse Hanford Company, Richland Washington, Robinson, S.M., T.E. Kent, W.D. Arnold, and J.R. Parrott, Jr., 1993, *The Development of a Zeolite System for Upgrade of the Process Waste Treatment Plant*, ORNL/TM-12063, Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, Tennessee.

Sackschewsky, M.R. and D.S. Landeen, 1992, *Fiscal Year 1991 100 Areas CERCLA Ecology Investigations*, WHC-EP-0448, Westinghouse Hanford Company, Richland, Washington.

Skeen, R.S., S.P. Luttrell, T.M. Brouns, B.S. Hooker, and J.N. Petersen, 1993, *In-Situ Bioremediation of Hanford Groundwater*, pp. 353-367.

Spooner, P., R. Wetzel, C. Spooner, C. Furman, E. Tokarski, G. Hunt, V. Hodge, and T. Robinson, 1985, *Slurry Trench Construction for Pollution Migration Control*, Noyes Publications, Mill Road, New Jersey.

S.S. Papadopulos & Associates, 1991, *A Modular Three-Dimensional Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems*, MT3D, Version 1.5.

Weiss, S. and R.M Mitchell, 1992, *A Synthesis of Ecological Data from the 100 Areas of the Hanford Site*, WHC-EP-0601, Westinghouse Hanford Company, Richland, Washington.

WHC 1991, *Waste Information Data System*, Westinghouse Hanford Company, Richland, Washington.

WHC 1993a, *100-HR-3 Area Groundwater Treatment Tests for Ex Situ Removal of Chromate, Nitrate, and Uranium (VI) by Precipitation/Reduction and/or Ion Exchange*, WHC-SD-EN-TC-003, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC 1993b, *Treatment Tests for Ex Situ Removal of Chromate, Nitrate, and Uranium (VI) from Hanford (100-HR-3) Groundwater Final Report*, WHC-SD-ER-DTR-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC 1993c, *Qualitative Risk Assessment for the 100-BC-5 Operable Unit*, WHC-SD-EN-RA-006, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC 1993d, *Qualitative Risk Assessment for the 100-BC-1 Operable Unit*, WHC-SD-EN-RA-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Williams, R. and G. Strand, 1990, *Radioactive Liquid Waste Volume Reduction System*, Pacific Nuclear Systems, Inc., NuPac Services Division, Inc., Columbia, South Carolina.

Winterkorn, H.F. and H. Fang, 1975, *Foundation Engineering Handbook*, Van Nostrand Reinhold Company, New York, New York.

Zheng, C., 1991, *PATH3D, Version 3.0, A Ground-Water Path and Travel-Time Simulator*, S.S. Papadopulos and Associates, Inc., Bethesda, Maryland.

THIS PAGE INTENTIONALLY
LEFT BLANK

APPENDIX A

100-BC-5 OPERABLE UNIT REPRESENTATIVE DATA ANALYSIS

1.0 INTRODUCTION

A risk assessment is being prepared in support of the FFS for the 100-BC-5 Groundwater Operable Unit. The focus of the risk assessment was defined at the April 8, 1994 meeting among Tri-Party unit managers, and the major assumptions to be used in the risk assessment, based on the agreements at the meeting, were outlined in a memorandum from Golder to Westinghouse dated April 12, 1994.

In the April 8th meeting, it was agreed that the only exposure pathway applicable for human exposures is potential groundwater flow into riverbank springs and the Columbia River. The only receptors identified under this pathway are recreational users who may ingest water from springs. The exposure concentrations likely to be available for human exposures are in near-river groundwater.

As stated in the April 12th memorandum, it is proposed that the average of the maximum concentrations of contaminants from the 4th and 5th sampling rounds from near-river groundwater monitoring wells be used to characterize contaminant exposure concentrations in the risk assessment. However, it was agreed that the use of this limited data set for risk assessment purposes is contingent upon the results of a representative data analysis to verify that this data set represents groundwater concentrations that are potentially available for human exposure at the riverbank.

The following analysis is a review of the data available for the 100-BC-5 Groundwater Operable Unit, and verifies that the use of the 4th and 5th rounds of data from near-river wells are representative of the contaminant concentrations available for exposure at the riverbank.

2.0 REPRESENTATIVE DATA ANALYSIS

The following representative data analysis consists of a comparative evaluation of data for three data sets for the 100-BC-5 Operable Unit: the entire operable unit data set, the near-river data set; and the late round, near-river data set. The entire operable unit data set is defined as five rounds of LFI sampling data from wells within the 100-BC-5 Operable Unit, including near-river wells. The near-river data set consists of five rounds of sampling data from the wells along the Columbia River only (wells B2-13, B3-1, B3-46, and B3-47). The late round near-river data set consists of 4th and 5th sampling round data (Spring 1993 and Fall 1993) from near-river wells in the 100-BC-5 Operable Unit.

The purpose of the representative data analysis is to a) determine if there are higher contaminant concentrations inland from the near-river wells (i.e., upgradient from near-river wells and the riverbank) that could potentially affect near-river exposure concentrations in the future; and b) determine whether the late-round near-river data set best represents groundwater concentrations potentially available for human exposure at the riverbank.

Table A-1 presents a summary of data from the three data sets for comparative purposes. This table includes maximum and minimum values from five rounds of 100-BC-5 data from the entire operable unit, as well as the number of samples with detected concentrations and the number of samples analyzed for each parameter with the exception of organic compounds. Organic compounds presented in this table are only those compounds that had detected concentrations in any of the five sampling rounds.

2.1 ELIMINATION OF NONDETECTED PARAMETERS

In order to evaluate the representativeness of the near-river data sets, it is necessary to evaluate the entire operable unit data set to establish equilibration trends and anomalies in the data, and to reduce the data sets by elimination of parameters that do not require further evaluation. These characteristics can then be compared to the near-river data sets to evaluate their representativeness. The following is an evaluation of the entire operable unit data set.

Parameters that are not detected or are detected at less than a 5% detection rate (number of detects/number of sample results per parameter) in all five sampling rounds throughout the entire operable unit are eliminated from further consideration. These parameters are indicated on Table A-1, and are listed below:

Radionuclides

Americium-241
Cesium-134
Cesium-137
Chromium-51
Cobalt-60
Europium-152
Europium-154
Iron-59
Plutonium-238
Plutonium-239/240
Potassium-40
Radium-226
Ruthenium-106
Thorium-228
Thorium-232
Zinc-65

Inorganic Constituents

Antimony
Beryllium
Cadmium
Cobalt
Mercury
Silver
Thallium
Cyanide

Wet Chemistry and Anions

Hydrazine
Phosphate
Sulfide

Organic Compounds

Acetone	Di-n-octylphthalate
Benzene	2-Hexanone
2-Butanone	Methylene chloride
Chlorobenzene	4-Methyl-2-pentanone
Diethylphthalate	1,1,2,2-Tetrachloroethane
Di-n-butylphthalate	

2.2 USE OF NEAR-RIVER DATA

The use of data from the near-river portion of the operable unit in the risk assessment is evaluated by review of concentrations in near-river wells compared to wells throughout the entire operable unit to determine whether concentrations are substantially different between the two data sets.

As shown on Table A-1, the maximum representative concentrations selected for the near-river data set are typically equivalent to those selected for the entire operable unit data set with some exceptions. The exceptions to this concept are parameters with upgradient concentrations that are higher than near-river concentrations. These parameters are arsenic, calcium, chromium, copper, lead, magnesium, nickel, potassium, vanadium, zinc, bis(2-ethylhexyl)phthalate, and trichloroethene. These exceptions are discussed below.

- Calcium, magnesium, and potassium are generally not toxic, and will not be evaluated in the risk assessment.

- Arsenic and vanadium are present in both the entire operable unit and at near-river locations at concentrations less than background, and therefore will not be evaluated in the risk assessment.

- Copper, lead, nickel, and zinc are present in the entire operable unit data set at concentrations above background, however, these parameters would pass preliminary risk-based screening, and therefore would not be evaluated in the risk assessment.

- Chromium, bis(2-ethylhexyl)phthalate, and trichloroethene are present in both the entire operable unit and near-river data sets at concentrations above background and would fail preliminary risk-based screening. Therefore, these parameters would generally be evaluated in the risk assessment. The maximum representative concentrations in the entire operable unit and near-river data sets are within the same order of magnitude for all three of these parameters and are not expected to result in significantly different risk levels.

Based on these observations, it is unlikely that there are plumes of contaminants containing substantially higher concentrations (compared to near-river concentrations) in the upgradient portion of the operable unit that could potentially affect near-river groundwater concentrations. Therefore, it is reasonable to assume that near-river concentrations would not increase significantly in the future.

2.3 USE OF LATE ROUND DATA

The use of late round sampling data in the risk assessment is evaluated by review of concentrations over the five sampling rounds to determine whether late round data are representative of groundwater concentrations available for exposure to humans. This evaluation includes data for the entire operable unit, including near-river data, in order to observe groundwater concentrations over time throughout the operable unit.

As described in Section 2.1, several parameters with less than 5% detection rates are eliminated from further evaluation. The remaining parameters are reviewed to determine representative concentrations for each parameter. As described in the LFI report (DOE-RL 1993b), data are evaluated for consistency between sampling rounds. If the concentration of a parameter is several orders of magnitude higher in the initial sampling rounds and equilibrates in later sampling rounds, the results from the initial sampling rounds are eliminated as inconsistent. Likewise, if a parameter concentration is anomalously higher in one sampling round compared to other rounds, that value is also eliminated as inconsistent.

Maximum representative concentrations for the entire operable unit data set are selected, for the most part, from the maximum concentrations detected in the operable unit from all five sampling rounds. However, there are several exceptions where equilibration has occurred or anomalies are present. The parameters exhibiting equilibration of concentrations or anomalies are described below and are accompanied by time-concentrations graphs to illustrate the fluctuations of concentrations over the five sampling rounds. The time and concentration graphs include data for wells exhibiting elevated concentrations, or wells with significant changes in concentrations. The wells used in these graphs are selected specifically for each contaminant depending on that contaminant's behavior in a well. Therefore, the wells presented in these graphs are specific to the contaminant of interest.

- Carbon-14 (Figure A-1) - Initial high concentrations in Fall 1992 (maximum = 410 pCi/L) dropped to equilibrated levels that are less than detection limits (generally <50 pCi/L) by Spring and Fall 1993, therefore the maximum representative concentration selected is "not detected".

- Tritium (Figure A-2) - Initial high concentrations (maximum = 24,000 pCi/L) dropped to relatively stabilized concentrations by Spring and Fall 1993 (maximum representative concentration = 15,000 pCi/L).

- Arsenic (Figure A-3) - Two anomalously high values (0.829 mg/L and 0.722 mg/L) are present in the Fall 1992 sample results. The next highest results are two orders of magnitude less (maximum representative concentration = 0.0059 mg/L) or not detected (generally <0.005 mg/L).

- Chromium (Figure A-4) - The maximum concentration of chromium (0.117 mg/L) was observed in well 199-B4-5 in the second round of sampling. However, duplicate samples from the same well collected on the same date have concentrations of 0.0845 mg/L and 0.0141 mg/L. Therefore, the highest result (0.117 mg/L) is considered anomalous. The second highest concentration (0.0845 mg/L), as shown on Figure A-4, and other initially high sample results in early rounds dropped to equilibrated levels (generally <0.030 mg/L) in Spring and Fall 1993 sample rounds, except in one well (well 199-B5-1), where Fall 1993 sample result (0.0639 mg/L) was higher than previous sample rounds. In the case of chromium, the Fall 1993 sample result, representing an increased concentration, is selected as the maximum representative concentration.

- Lead (Figure A-5) - Anomalously high values (maximum = 0.529 mg/L) are present in Fall 1992 sample results. The next highest values are two orders of magnitude less (maximum representative concentration = 0.0079 mg/L), or are not detected (generally <0.003 mg/L).

- Manganese (Figure A-6) - Initially high sample results (between 0.015 mg/L and 0.030 mg/L) in early rounds dropped to equilibrated levels (generally <0.005 mg/L) in Spring and Fall 1993 sample rounds, with the exception of one near-river well (well 199-B3-1). The maximum value detected in the entire operable unit (0.101 mg/L) was present in well 199-B3-1 in Fall 1993. However, the maximum value is an order of magnitude higher than previous sample results in the same well (second highest result = 0.0107 mg/L). The second highest result is selected for the maximum representative concentration for manganese.

- Nickel (Figure A-7) - Initial high concentrations (maximum = 0.0748 mg/L) in Spring and Fall 1992 dropped to relatively stabilized concentrations by Spring and Fall 1993 (generally <0.020 mg/L). The maximum representative concentration selected for nickel is 0.024 mg/L.

- Selenium (Figure A-8) - One anomalously high value (maximum = 0.0319 mg/L) detected in Fall 1992 is one order of magnitude higher than all other detected selenium concentrations. All other detected concentrations are interspersed with non-detected concentrations (generally <0.020 mg/L), and rejected data throughout the sampling period for all wells. Since there were no consistent detects in any wells in the entire operable unit, the maximum representative concentration selected is "not detected".

- Vanadium (Figure A-9) - The maximum detected concentration (0.0184 mg/L) from the five sampling rounds occurred in well 199-B4-5 in Fall 1992. Two other sample results from the same well from the same sample round are an order of magnitude lower (0.0097 mg/L and 0.0077 mg/L), therefore, the maximum value is considered inconsistent and is eliminated. The second highest detected value (0.0143 mg/L) is selected as the maximum representative concentration.

- Zinc (Figure A-10) - Initially high sample results (maximum = 0.0673 mg/L) in early rounds dropped to equilibrated levels (generally <0.030 mg/L) in Spring and Fall 1993 sample rounds. The second highest detected value (0.0232 mg/L) is selected as the maximum representative concentration.

As observed in the discussions above, parameter concentrations in later sampling rounds, with some exceptions, typically equilibrate to concentrations one to three orders of magnitude lower than initial sampling round results. The sample results typically indicate that equilibration has occurred by the Spring and Fall 1993 sampling rounds. Exceptions to this concept are chromium and manganese, which had increased concentrations in later sampling rounds. The later sampling round results are used for maximum representative concentrations for both chromium and manganese.

Based on the data reviewed above, it is reasonable to assume that data from late (Spring and Fall 1993) sampling rounds are representative of the groundwater concentrations in the 100-BC-5 Operable Unit. In the case of chromium and manganese, the increased sample results occurred in the Fall 1993 sample round.

2.4 CONCLUSIONS

The use of the near-river data subset, as opposed to the entire operable unit data set should not affect the specific contaminants of concern selected for use in the risk assessment, or result in substantially different risks from potential human exposures. It is expected that the use of late round data would ensure that equilibrated data is used in the risk assessment, and would therefore serve to eliminate data that are not representative of current groundwater conditions. Based on these observations, it is appropriate to use late round near-river data to evaluate potential exposures at the riverbank for the 100-BC-5 Operable Unit risk assessment.

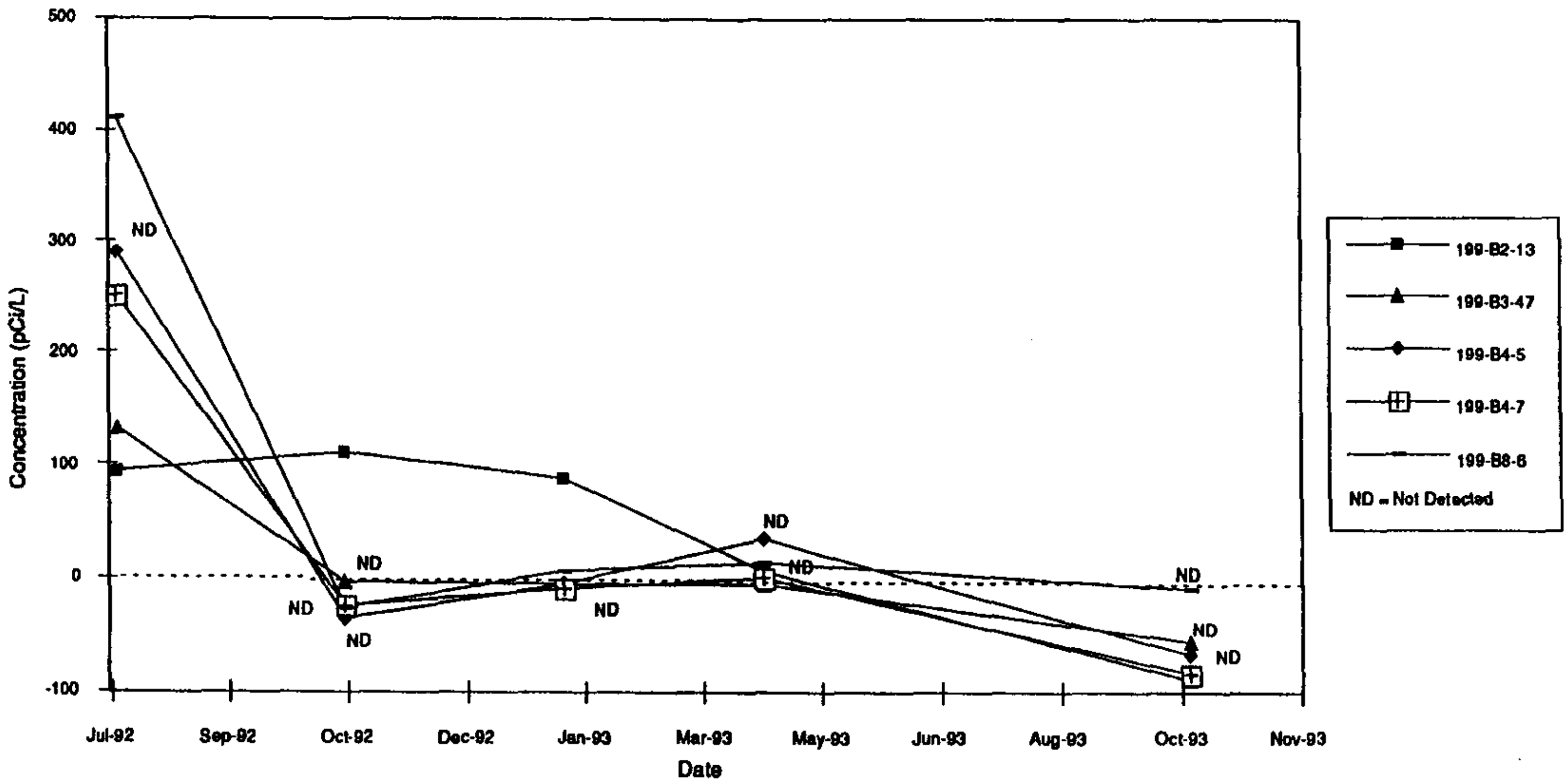
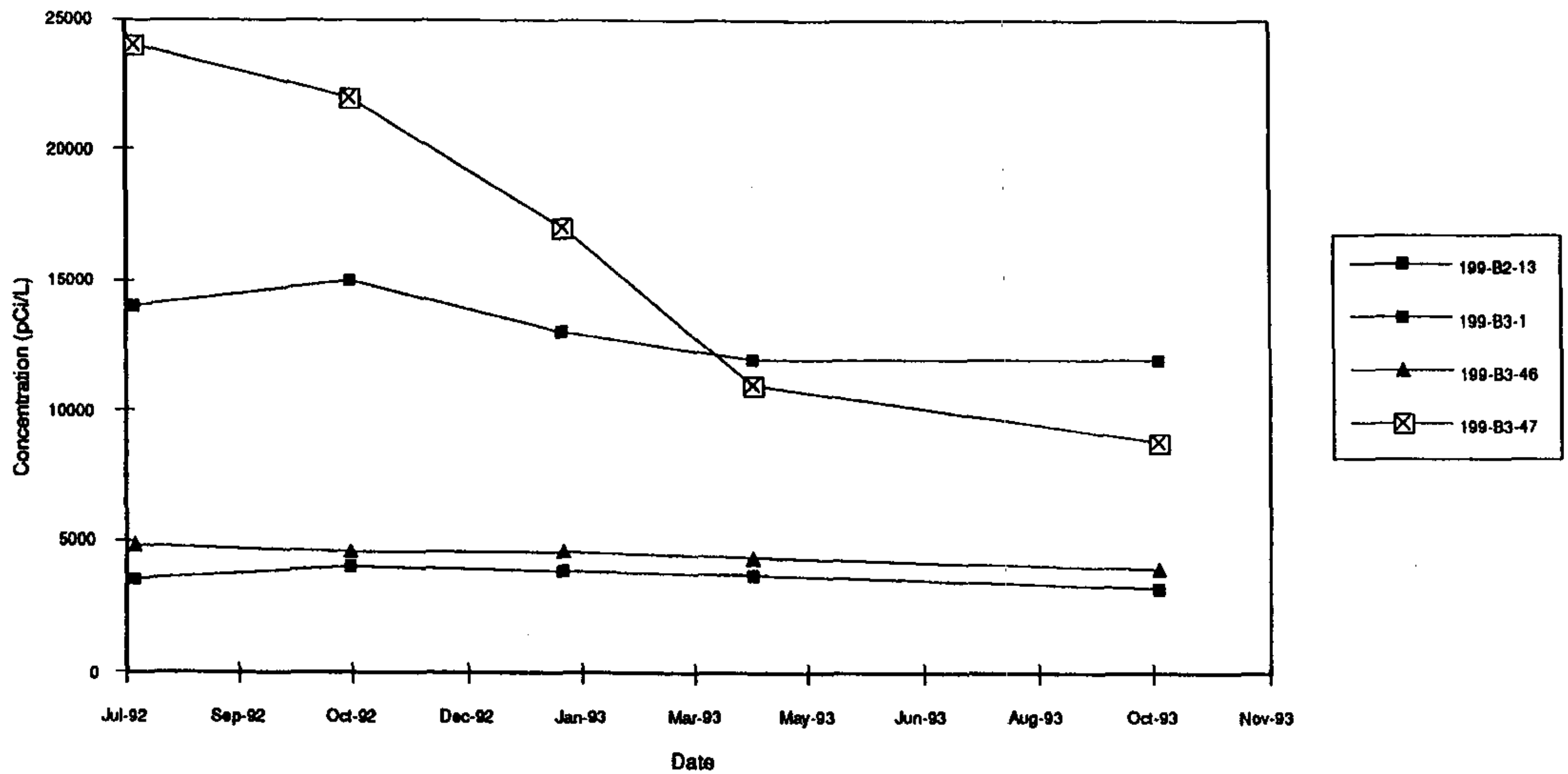


Figure A-1 Carbon-14 Time-Concentration Graph

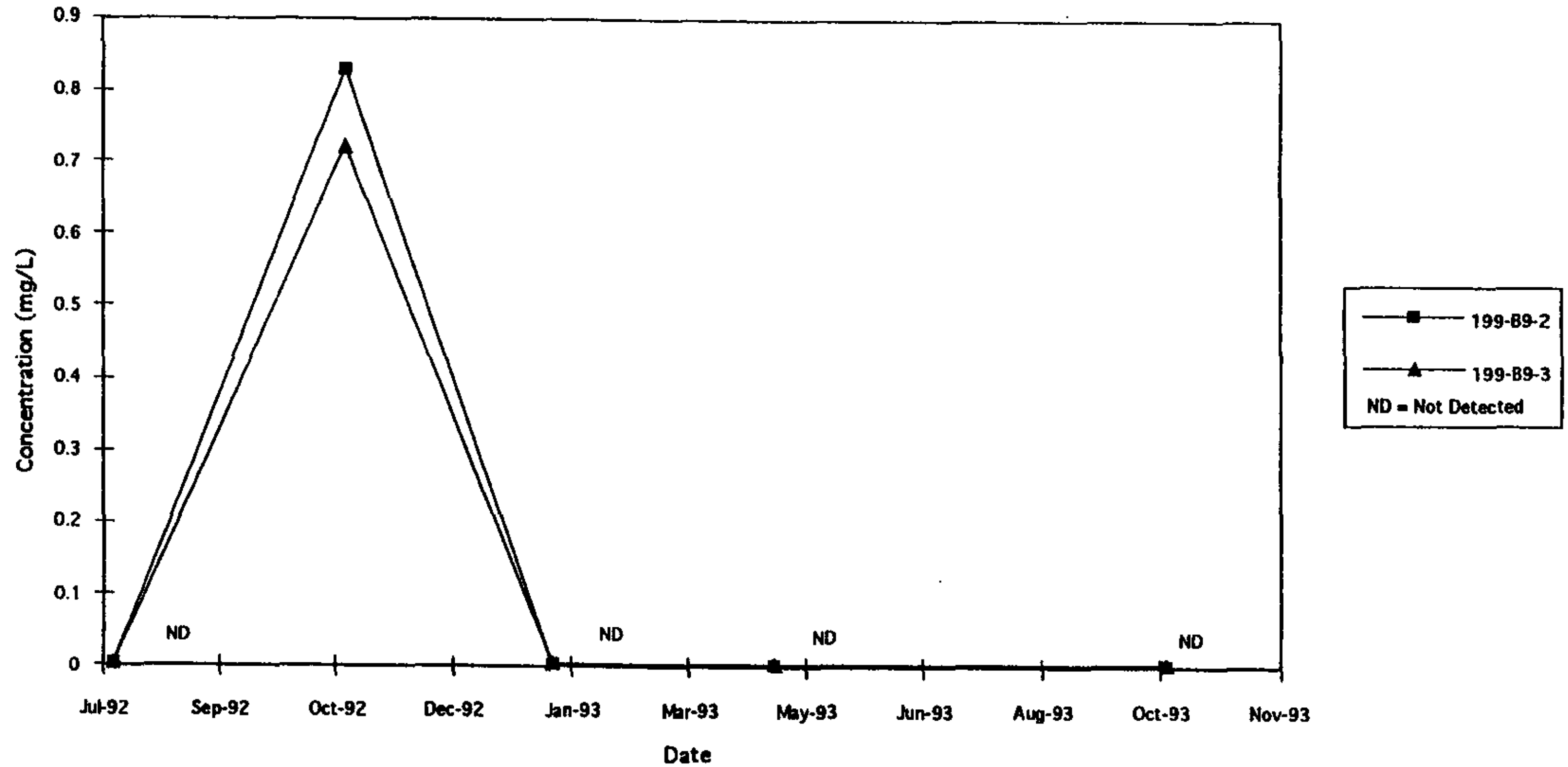
923-E009.DC2/50040/8-10-94

Figure A-2 Tritium Time-Concentration Graph



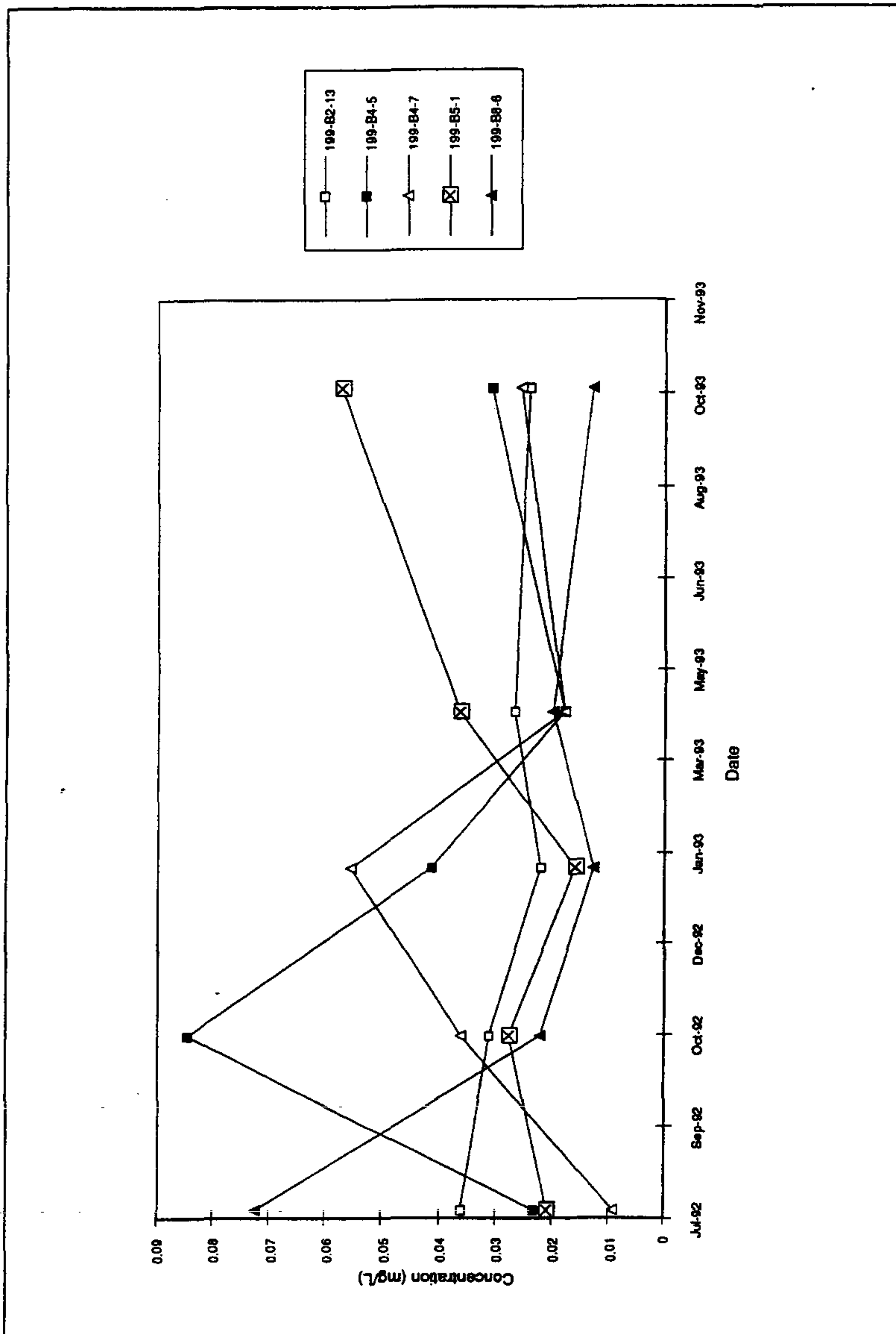
923-E009.DC2/50037/8-10-94

Figure A-3 Arsenic Time-Concentration Graph



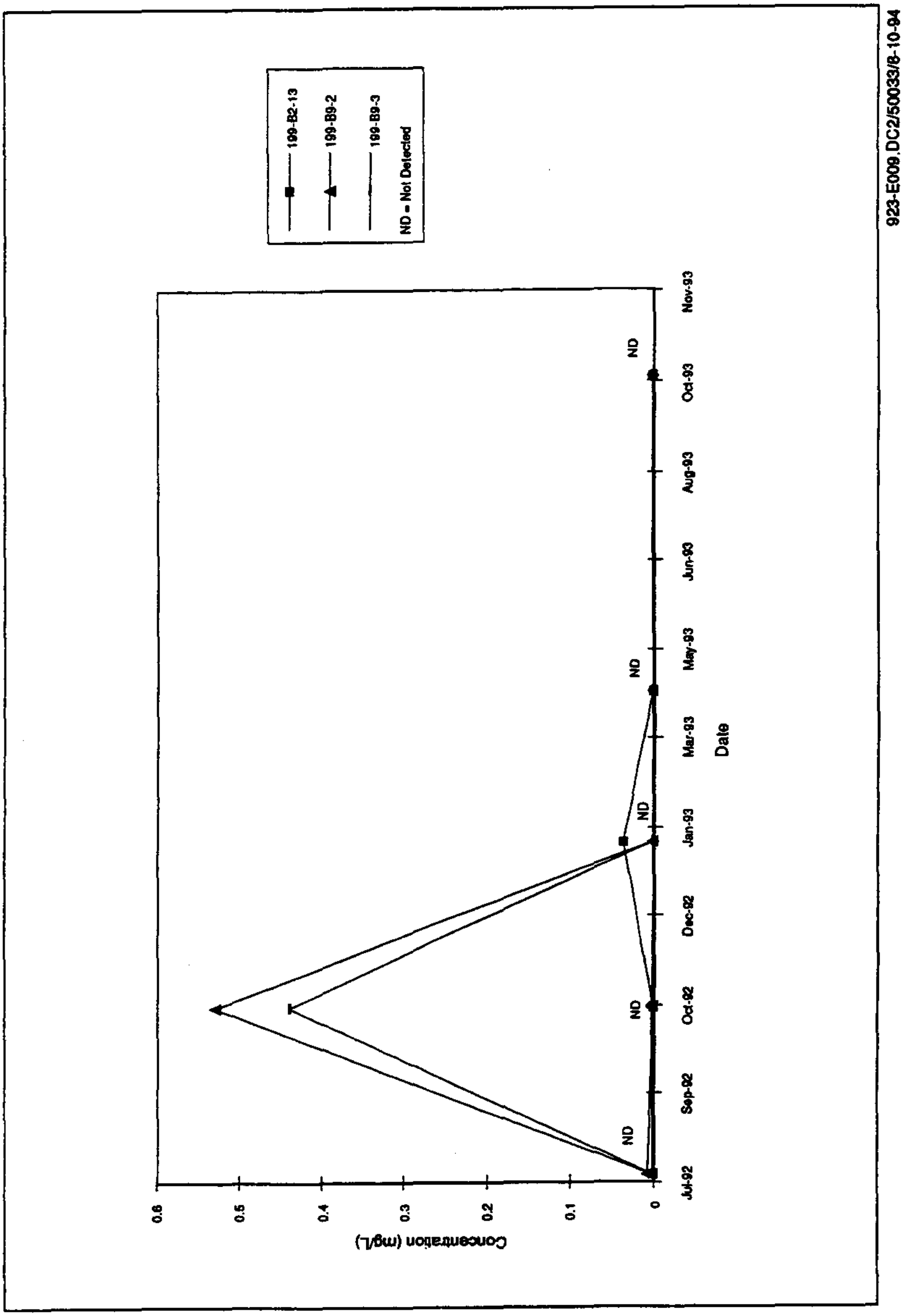
923-E009.DC2/50032/8-10-94

Figure A-4 Chromium Time-Concentration Graph



923-E009.DC2/50036/8-9-94

Figure A-5 Lead Time-Concentration Graph



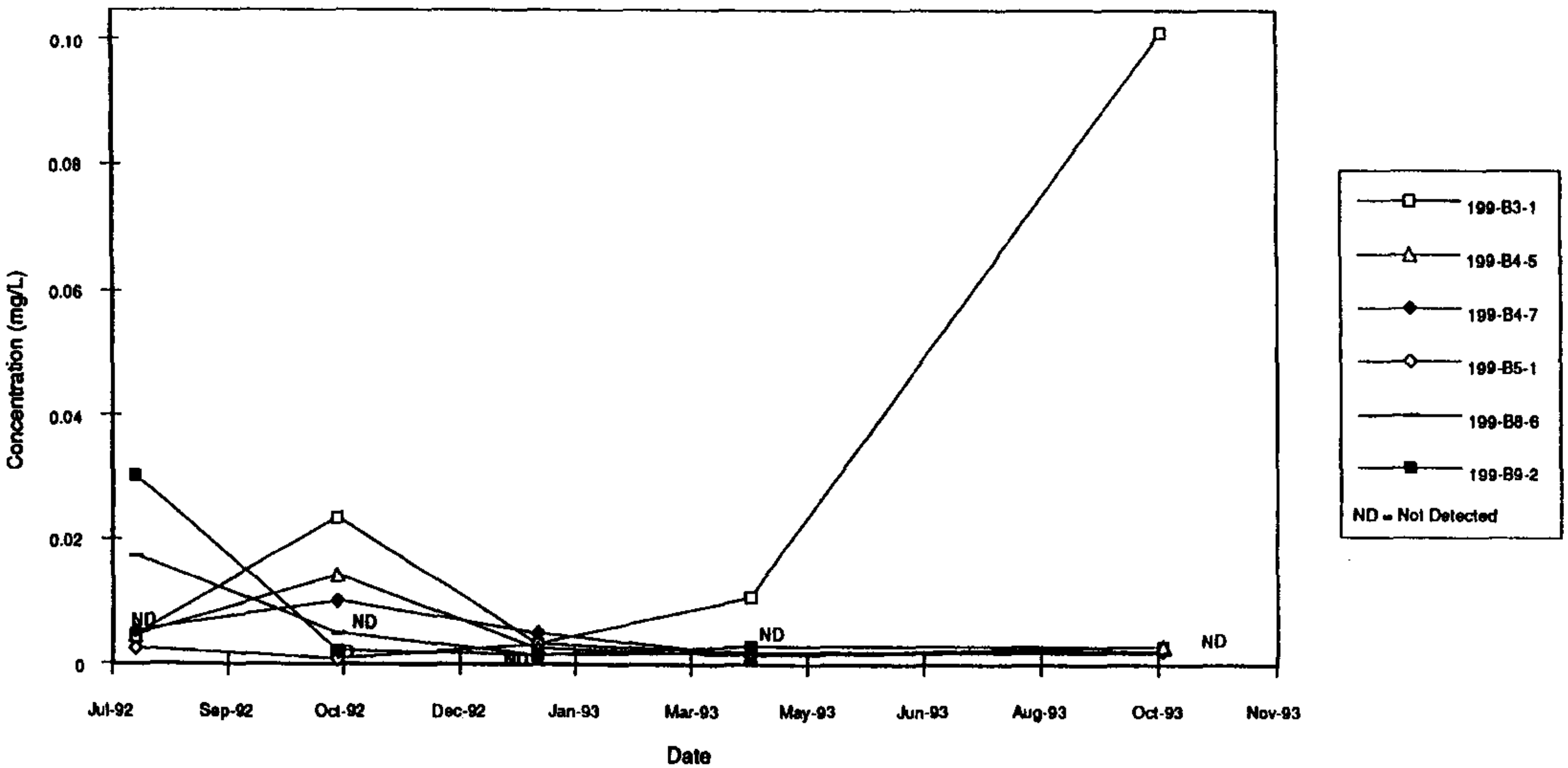
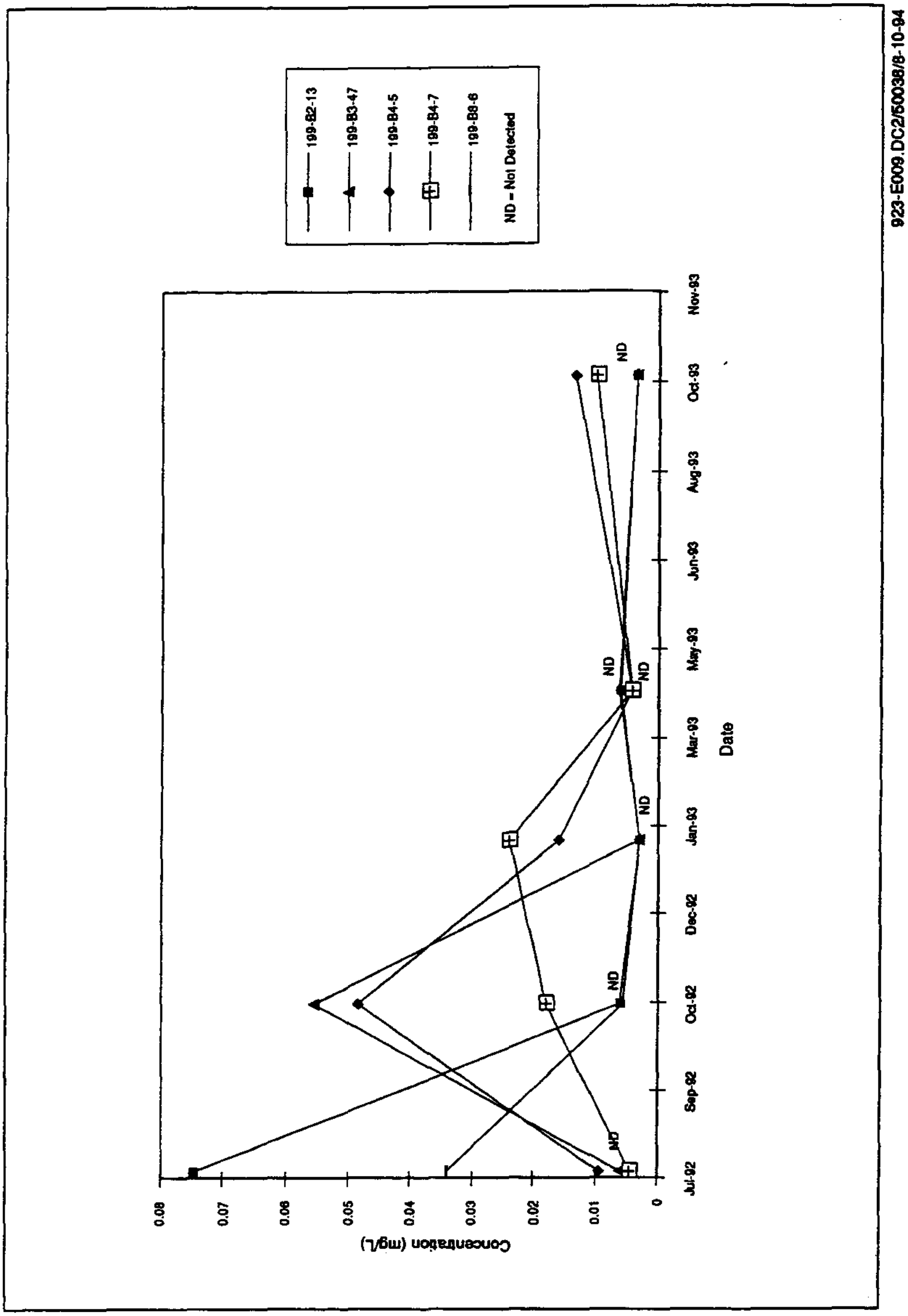


Figure A-6 Manganese Time-Concentration Graph

923-E009.DC2/50035/8-9-94

Figure A-7 Nickel Time-Concentration Graph



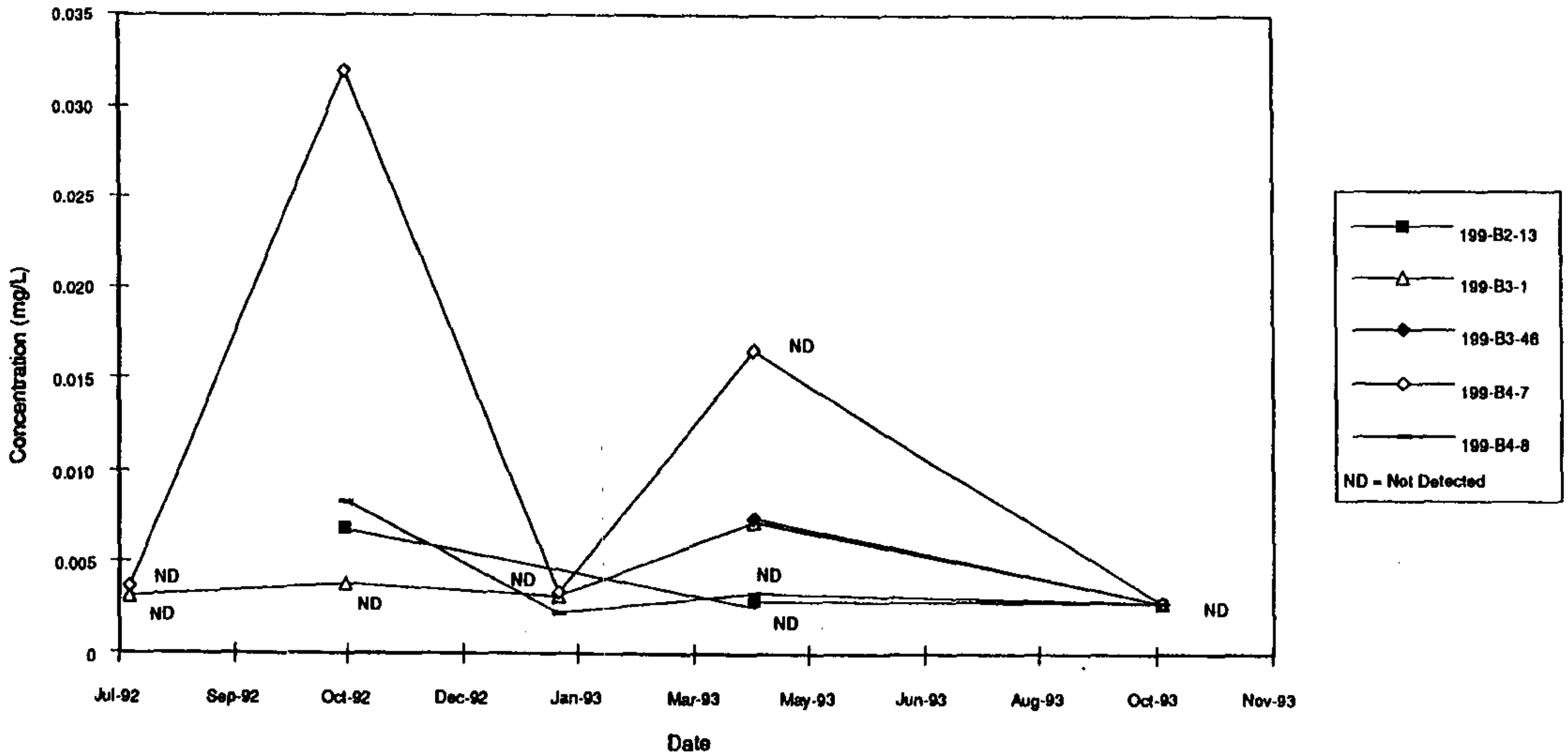


Figure A-8 Selenium Time-Concentration Graph

923-E009.DC2/50031/8-9-94

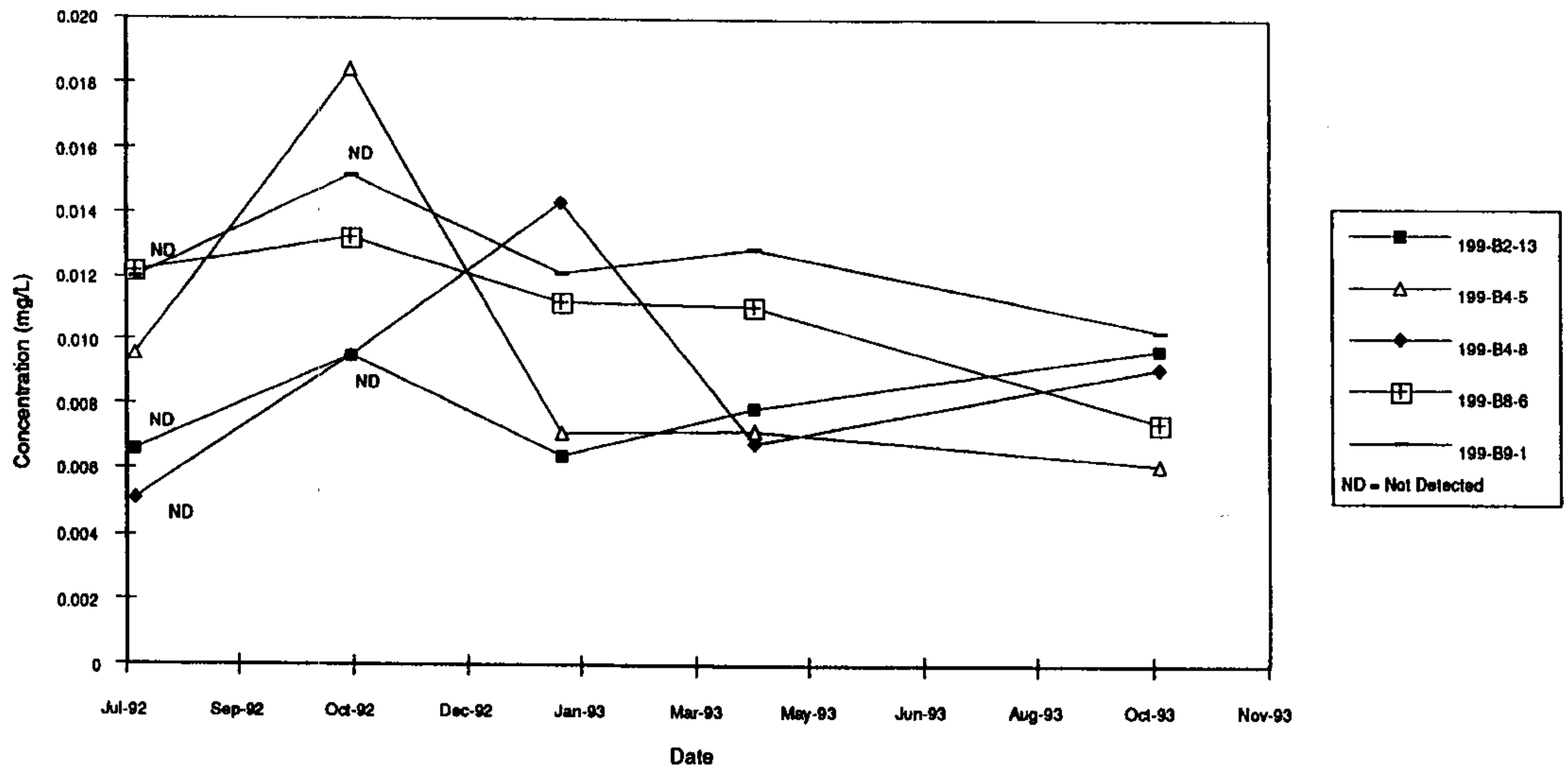


Figure A-9 Vanadium Time-Concentration Graph

923-E009.DC2/50039/8-9-94

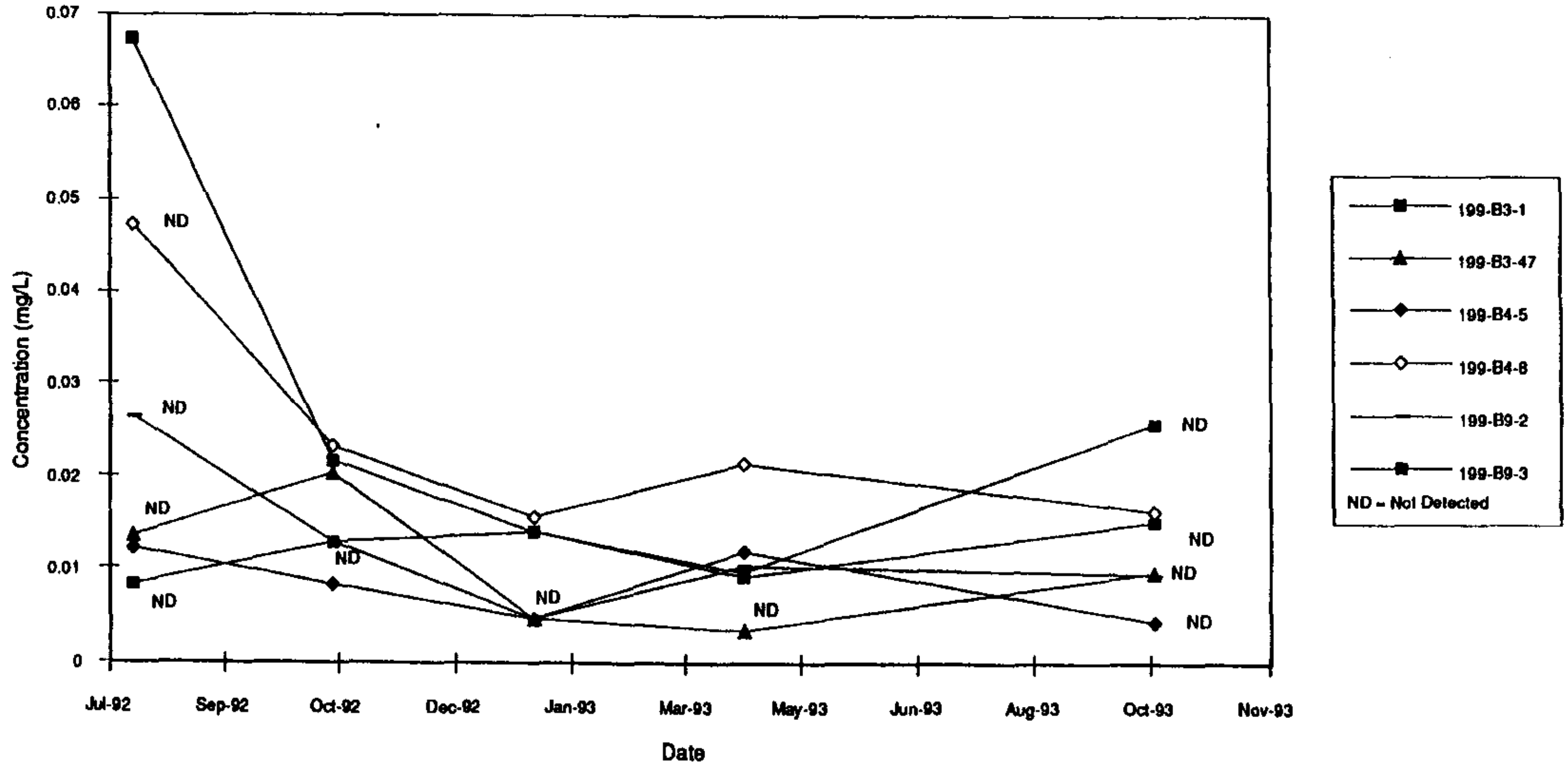


Figure A-10 Zinc Time-Concentration Graph

Table A-1 Summary of Data for the 100-BC-5 Operable Unit
(page 1 of 3)

Parameter	Units	All 100-BC-5 OU Data				Maximum Representative Concentration Entire OU	Maximum Representative Concentration NR	Maximum Representative Concentration LRNR	Number of Values >Rep Entire OU	Number of Values >Rep NR	Number of Values >Rep LRNR
		Maximum Result	Minimum Result	Number of Detects	Number of Samples						
RADIONUCLIDES											
Americium-241	pCi/L	0.049	-0.033U	2	71	ND	ND	ND	2	0	0
Carbon-14	pCi/L	410	-110U	11	92	ND	ND	ND	11	4	3
Cesium-134	pCi/L	20U	-2.9U	0	71	ND	ND	ND	0	0	0
Cesium-137	pCi/L	9.2	-1.6U	1	71	ND	ND	ND	1	0	0
Chromium-51	pCi/L	800U	100U	0	70	ND	ND	ND	0	0	0
Cobalt-60	pCi/L	20U	2U	0	71	ND	ND	ND	0	0	0
Europium-152	pCi/L	30U	-15U	0	71	ND	ND	ND	0	0	0
Europium-154	pCi/L	20U	8U	0	71	ND	ND	ND	0	0	0
Gross Alpha	pCi/L	10	-3.6R	14	91	10	10	10	0	0	0
Gross Beta	pCi/L	290	8.4U	77	91	290	290	245	0	0	0
Iron-59	pCi/L	100U	-3U	0	71	ND	ND	ND	0	0	0
Plutonium-238	pCi/L	0.017	-0.016U	1	70	ND	ND	ND	1	1	1
Plutonium-239/240	pCi/L	0.015	-0.009U	2	71	ND	ND	ND	2	2	1
Potassium-40	pCi/L	200	70U	3	71	ND	ND	ND	3	0	0
Radium-226	pCi/L	30	-40U	2	71	ND	ND	ND	2	0	0
Ruthenium-106	pCi/L	130U	3.8U	0	71	ND	ND	ND	0	0	0
Strontium-90	pCi/L	150	-0.34U	62	90	150	150	125	0	0	0
Technetium-99	pCi/L	130	12	86	91	130	130	110	0	0	0
Thorium-228	pCi/L	40U	-0.33U	1	71	ND	ND	ND	1	0	0
Thorium-232	pCi/L	80U	30U	0	70	ND	ND	ND	0	0	0
Tritium	pCi/L	24000	1500	89	91	15000	15000	12000	3	3	0
Uranium (Total)	pCi/L	2.2	0.55	68	71	2.2	2.2	2.2	0	0	0
Zinc-65	pCi/L	40U	-4.4U	0	71	ND	ND	ND	0	0	0
INORGANIC CONSTITUENTS											
Aluminum	mg/L	1.24	0.0106U	33	95	1.24	1.24	0.65	0	0	0
Antimony	mg/L	0.06U	0.0092U	0	95	ND	ND	ND	0	0	0
Arsenic	mg/L	0.829	0.0019U	30	95	0.0059	ND	ND	2	0	0
Barium	mg/L	0.0592	0.0044	93	95	0.0592	0.0592	0.048	0	0	0
Beryllium	mg/L	0.0015	0.0002U	3	95	ND	ND	ND	3	0	0
Cadmium	mg/L	0.0022	0.001U	6	95	ND	ND	ND	6	0	0

Table A-1 Summary of Data for the 100-BC-5 Operable Unit
(page 2 of 3)

Parameter	Units	All 100-BC-5 OU Data				Maximum Representative Concentration Entire OU	Maximum Representative Concentration NR	Maximum Representative Concentration LRNR	Number of Values >Rep Entire OU	Number of Values >Rep NR	Number of Values >Rep LRNR
		Maximum Result	Minimum Result	Number of Detects	Number of Samples						
Calcium	mg/L	56.8	32.3	95	95	56.8	53.8	52.8	0	0	0
Chromium	mg/L	0.117	0.0041U	84	95	0.0639	0.036	0.0254	3	0	0
Cobalt	mg/L	0.0107U	0.0013U	0	95	ND	ND	ND	0	0	0
Copper	mg/L	0.0117	0.0019U	17	95	0.0117	ND	ND	0	1	1
Iron	mg/L	3.6	0.0053U	53	95	1.62	1.62	0.9	1	1	0
Lead	mg/L	0.529	0.0012U	37	95	0.0079	0.0047	0.0040	4	1	0
Magnesium	mg/L	11.9	6.18	95	95	11.9	9.99	9.67	0	0	0
Manganese	mg/L	0.101	0.0008U	40	95	0.0107	0.0107	0.0068	7	3	1
Mercury	mg/L	0.00014	0.0001U	4	95	ND	ND	ND	4	0	0
Nickel	mg/L	0.0748	0.0026U	32	95	0.0241	0.0078	0.0078	5	2	0
Potassium	mg/L	6.64	1.76	95	95	6.64	4.45	4.09	0	0	0
Selenium	mg/L	0.0319	0.002U	11	95	ND	ND	ND	11	4	3
Silver	mg/L	0.004	0.0023U	4	95	ND	ND	ND	4	0	0
Sodium	mg/L	14.3	9.21	95	95	14.3	14.3	14.0	0	0	0
Thallium	mg/L	0.0039	0.0009U	2	95	ND	ND	ND	2	0	0
Vanadium	mg/L	0.0184	0.0025U	57	95	0.0143	0.0097	0.0088	1	0	0
Zinc	mg/L	0.0673	0.0026U	25	95	0.0232	ND	ND	1	3	1
Cyanide	mg/L	0.0238	0.010U	1	77	ND	ND	ND	1	0	0
WET CHEMISTRY AND ANIONS											
Alkalinity	mg/L	115	93	72	72	115	112	112	0	0	0
Ammonia as N	mg/L	0.4	0.05	11	71	0.4	0.4	ND	0	0	0
Chemical Oxygen Demand	mg/L	30	5U	4	71	30	30	ND	0	0	0
Chloride	mg/L	13.8	4.6	73	73	13.8	10.1	9.2	0	0	0
Conductivity	μmhos/cm²	447	262	93	93	447	424	421	0	0	0
Fluoride	mg/L	0.5	0.1	87	93	0.5	0.5	0.3	0	0	0
Hydrazine	mg/L	0.003U	0.003U	0	55	ND	ND	ND	0	0	0
Nitrate/Nitrite as N	mg/L	6.9	0.45	71	71	6.9	6.81	6.42	0	0	0
pH	std units	8.3	7	82	94	7.0-8.3	7.8-8.1	7.9-8.1	0	0	0
Phosphate	mg/L	0.4	0.04U	3	73	ND	ND	ND	3	1	0
Sulfate	mg/L	68.2	27	93	93	68.2	53	50	0	0	0
Sulfide	mg/L	1	0.1U	4	69	ND	ND	ND	4	1	0

Table A-1 Summary of Data for the 100-BC-5 Operable Unit
(page 3 of 3)

Parameter	Units	All 100-BC-5 OU Data				Maximum Representative Concentration Entire OU	Maximum Representative Concentration NR	Maximum Representative Concentration LRNR	Number of Values >Rep Entire OU	Number of Values >Rep NR	Number of Values >Rep LRNR
		Maximum Result	Minimum Result	Number of Detects	Number of Samples						
Total Dissolved Solids	mg/L	294	151	71	72	294	261	261	0	0	0
Total Organic Carbon	mg/L	10	0.5U	33	55	2.5	1.7	0.62	1	0	0
Total Organic Halides	mg/L	0.136	0.005U	6	55	ND	ND	ND	6	3	1
ORGANIC COMPOUNDS (detected only)											
Acetone	mg/L	0.012	0.002	3	68	ND	ND	ND	0	0	0
Benzene	mg/L	0.005	0.001	2	68	ND	ND	ND	2	0	0
Bis(2-Ethylhexyl)Phthalate	mg/L	0.069	0.0006	17	66	0.069	0.035	0.012	0	0	0
2-Butanone	mg/L	0.005	0.005	1	69	ND	ND	ND	1	1	1
Chlorobenzene	mg/L	0.002	0.002	1	68	ND	ND	ND	1	0	0
Chloroform	mg/L	0.002	0.002	1	68	ND	ND	ND	1	0	0
Diethylphthalate	mg/L	0.0007	0.0007	1	66	ND	ND	ND	1	0	0
Di-n-butylphthalate	mg/L	0.002	0.001	3	68	ND	ND	ND	3	0	0
Di-n-octylphthalate	mg/L	0.002	0.002	1	68	ND	ND	ND	1	0	0
2-Hexanone	mg/L	0.004	0.003	2	69	ND	ND	ND	2	0	0
Methylene chloride	mg/L	0.004	0.003	3	66	ND	ND	ND	3	1	0
4-Methyl-2-pentanone	mg/L	0.002	0.001	2	68	ND	ND	ND	2	1	1
1,1,2,2-Tetrachloroethane	mg/L	0.001	0.001	1	68	ND	ND	ND	1	0	0
Toluene	mg/L	0.009	0.001	9	69	0.009	0.009	0.009	0	0	0
Trichloroethene	mg/L	0.003	0.001	26	68	0.003	0.002	0.001	0	0	0

Note: Shading indicates parameter is detected at greater than 5% detection rate, and is retained from evaluation in the risk assessment.
OU = Operable Unit
NR = Near-river well data only (wells B2-13, B3-1, B3-46, B3-47)
LRNR = Late Round Near-River data only (average of maximum results from 4th and 5th sampling rounds at near-river wells)
ND = Not detected
U = Not detected, value given is detection limit

APPENDIX B

100-BC-5 OPERABLE UNIT RISK ASSESSMENT

1.0 INTRODUCTION

The 100-BC-5 Operable Unit is a groundwater unit located within the 100 B/C Area of the Hanford Site (Figure B-1). The 100-BC-5 Operable Unit includes the groundwater below the 100 B/C Area source operable units plus the adjacent groundwater, surface water, sediments and aquatic biota impacted by 100 B/C Area operations. Figure B-2 shows the approximate boundaries of the 100-BC-5 Operable Unit.

The waste units in the 100-BC-1 and 100-BC-2 Operable Units are the sources of groundwater contamination at the 100-BC-5 Operable Unit. Based on a previous LFI and QRA at the 100-BC-1 Operable Unit (WHC 1993d), several waste units at the 100-BC-1 Operable Unit have been identified as candidates for IRM. A record of decision (ROD) will be developed concurrently for each of these waste units. Similar strategies are in place to address the sources of groundwater contamination in the 100-BC-2 Operable Unit.

A QRA was conducted in support of an LFI for the 100-BC-5 Operable Unit and to determine a need for an IRM. The results of the LFI indicated that an IRM is not warranted. However, the Tri-Party unit managers agreed to conduct a FFS for the 100-BC-5 Operable Unit to determine the feasibility of selected remedial actions (including "no action") for this operable unit. This risk assessment has been prepared to support the consideration of the no action alternative included in the FFS for the 100-BC-5 Operable Unit. The application of the Hanford Past Practice Strategy (DOE-RL 1991a) at the 100-BC-5 Operable Unit is discussed in detail in the *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-5 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1992d).

A risk assessment is an analysis of the potential adverse health effects caused by hazardous substances at a site under an assumption of no remedial action. This report provides an assessment of the threats posed to human health by the COPC that have been detected at the 100-BC-5 Operable Unit. This risk assessment is prepared based on the assumption that once the sources of groundwater contamination are remediated, groundwater contaminant concentrations will not increase from current concentrations. Therefore, risks associated with future groundwater concentrations are not evaluated in this risk assessment, as they are assumed to be equal or less than those associated with current conditions.

1.1 PURPOSE AND SCOPE OF REPORT

The purpose of this risk assessment for the 100-BC-5 Operable Unit is to focus on a limited set of potential human exposure scenarios in order to provide sufficient information that will assist the Tri-Party signatories in making defensible decisions regarding a ROD. Currently, there is no groundwater use at the 100-BC-5 Operable Unit. However, there may be use of spring and river water potentially affected by groundwater from the 100-BC-5 Operable Unit. The potential risks associated with the use of the springs and river should be addressed in order to make sound, defensible decisions regarding this groundwater operable unit.

One exposure scenario is evaluated in this risk assessment, as agreed by the Tri-Party unit managers (April 8, 1994). The exposure scenario is the use of springs and river water potentially affected by groundwater from the 100-BC-5 Operable Unit by recreational users. Two exposure pathways (ingestion of spring and river water in the vicinity of the 100-BC-5 Operable Unit, and ingestion of fish from the Columbia River in the vicinity of the 100 B/C Area) are evaluated, as agreed by the Tri-Party unit managers.

Environmental receptors are not evaluated in this risk assessment. An evaluation of the potential risks to environmental receptors associated with the Columbia River is in preparation that assesses contaminant contributions from several sources and incorporates environmental parameters beyond the scope of the 100-BC-5 Operable Unit. Therefore, the evaluation of risks to environmental receptors is deferred to the Columbia River Comprehensive Impact Assessment and is not conducted in this risk assessment.

The data used in this risk assessment, as agreed by the Tri-Party unit managers, are from the last two rounds (Spring and Fall 1993) of LFI groundwater sampling from near-river wells in the 100-BC-5 Operable Unit. The available data are evaluated through the use of deterministic exposure and toxicity assessments to characterize the risks or hazards associated with the 100-BC-5 operable unit groundwater. The risk assessment is conducted using the *Hanford Site Risk Assessment Methodology* (DOE-RL 1994c) as guidance.

1.2 DATA SOURCES

The general sources of information used to prepare the risk assessment are discussed in this section. Groundwater monitoring data from the LFI are available for the 100-BC-5 Operable Unit, and groundwater background data are available for the Hanford Site, as described below. Historical groundwater data are not used in this risk assessment as they are not considered representative of current groundwater conditions. A more comprehensive discussion of groundwater data sources is provided in the LFI report for the 100-BC-5 Operable Unit (DOE-RL 1993b).

Fish tissue data for the evaluation of fish ingestion from the Columbia River near the 100 Area are available from the *Surface Environmental Data Report* as presented in the *Hanford Site Environmental Data for Calendar Year 1992 - Surface and Columbia River* (Bisping and Woodruff 1992). The fish tissue data is discussed in Section 2.0 of the FFS and in Section 1.2.3 of this appendix.

1.2.1 LFI Groundwater Data for the 100-BC-5 Operable Unit

A LFI was completed in accordance with the 100-BC-5 Operable Unit work plan (DOE-RL 1992d) and the *Description of Work for the 100-BC-5 Operable Unit* (Roberts 1992) to provide additional information and characterization needed to support selection, design, and implementation of IRM for the 100-BC-5 Operable Unit. Monitoring wells were installed during the LFI to define groundwater quality in areas of potential exposure (e.g., near springs along the Columbia River shoreline that are downgradient of contamination sources), to define groundwater quality immediately downgradient of high-priority waste sites, and to identify potential sources of groundwater contamination.

Existing wells were surveyed and inspected (not including wells installed as part of the LFI) to evaluate their "fitness-for-use" for environmental monitoring (Ledgerwood 1991). All of the existing wells in the 100-BC-5 Operable Unit were judged to be usable for LFI sampling. Data from the upper, unconfined aquifer are used in this evaluation. Data from wells screened in the lower, confined aquifers are eliminated because they are not analogous to data from unconfined aquifer wells. Figure B-3 is a map showing the locations of new and existing monitoring wells within the 100-BC-5 Operable Unit.

Data from five LFI sampling rounds (Summer 1992, Fall 1992, Winter 1993, Spring 1993, and Fall 1993) are available for the 100-BC-5 Operable Unit. Samples were analyzed for volatile, semi-volatile, pesticide/polychlorinated biphenyls, inorganic, radionuclide, and wet chemistry parameters according to the description of work (Roberts 1992) and the Quality Assurance Project Plan for the 100-BC-5 Operable Unit work plan (DOE-RL 1992d). Laboratories performing the analysis were Weston Analytic Laboratory of Lionville, Pennsylvania and TMA-Norcal Laboratory of Richmond, California.

The LFI data collected for 100-BC-5 Operable Unit were analyzed using methods specified in EPA SW-846 with contract laboratory program type deliverables. The first round of LFI data was 100% validated. The following rounds of LFI data were 100% verified and 10% validated. Based on the validation activities, data results were assigned qualifiers in accordance with criteria specified in the *Data Validation Procedures for Chemical Analyses* (Bechtold 1992). Data that are termed "usable" (detected compounds or estimated "J" values) can be used in the risk assessment. Data that were rejected for quality control problems are eliminated from evaluations; however, data that were rejected due to non-quality control problems (such as incomplete paperwork) are retained.

1.2.2 Hanford Site Groundwater Background Data

Several inorganic parameters occur naturally in groundwater at the Hanford Site. The naturally-occurring parameters in groundwater for the entire Hanford Site were characterized in *Hanford Site Groundwater Background* (DOE-RL 1992e). As part of this characterization, provisional threshold levels based on the 95% upper confidence limit of the sitewide data were defined for 40 inorganic groundwater parameters. The provisional threshold levels are used in this evaluation to represent background concentrations for inorganic parameters in the 100-BC-5 Operable Unit.

Currently, there are no sitewide background concentrations that have been agreed upon for organic or radionuclide analytes except for total uranium, gross alpha, and gross beta activity. Detected levels of organic and radionuclide analytes (with the exception of total uranium, gross alpha and gross beta) are assumed to be contaminants and are not compared to background (DOE-RL 1994c). Total uranium, gross alpha, and gross beta are compared to provisional threshold values to determine if they are above naturally-occurring levels.

1.2.3 Hanford Reach Fish Tissue Data

Muscle tissue and carcass radionuclide wet weight data are available for whitefish, carp, and bass taken from the Columbia River at the 100 Area (Bisping and Woodruff 1992). These fish species are used to represent the year-round resident fish of the Columbia River that are available for consumption.

The ingested portion of these fish is best represented by muscle tissue data; however, the data indicate that the radionuclides of interest are not detected in the muscle tissue data for these fish. This is likely because the radionuclides of interest (such as strontium-90) tend to bioaccumulate in bone rather than muscle tissue. Carcass data are used instead of muscle tissue data in this evaluation. Since the radionuclide concentrations are lower in the fish muscle tissue than in the carcasses, and the fish muscle tissue is the ingested portion of the fish, the resulting risks from this evaluation may be overestimates of potential risks.

2.0 CHARACTERIZATION OF CONTAMINANTS OF POTENTIAL CONCERN

The data to be used in the risk assessment are reviewed prior to evaluation to select representative data. Representative data are compared to background concentrations to identify an initial list of contaminants that are evaluated in the preliminary risk-based screening. The contaminants with concentrations in excess of the preliminary risk-based screening values are identified as COPC and are retained for risk assessment evaluations.

2.1 DATA SELECTION

The data used in this risk assessment, as agreed by the Tri-Party unit managers, are unfiltered groundwater data from the last two LFI sampling rounds (Spring and Fall 1993) of near-river wells at the 100-BC-5 Operable Unit. The maximum representative concentrations from each of the last two sampling rounds of the four near-river wells are averaged to provide the exposure point concentration used in the risk assessment.

A representative data analysis was performed prior to the risk assessment to verify that the last two rounds of data are representative of the groundwater available at the riverbank. As part of the representative data analysis, data were reviewed for frequency of detection, consistency, and equilibration, as described below.

Since the near-river portion of the 100-BC-5 Operable Unit is a limited data set, the elimination of contaminants due to infrequent detection is based on a review of the data from all five LFI sampling rounds for the entire operable unit, except where otherwise noted. Parameters that are not detected or detected at less than a 5% detection rate in five rounds of data for the entire operable unit are eliminated from further evaluations. This approach is consistent with Risk Assessment Guidance of Superfund (RAGS) (EPA 1989). The contaminants eliminated due to infrequent detection are listed in Appendix A of this report.

Evaluations for consistency include the comparison of maximum concentrations over the five LFI sampling rounds to identify anomalous values and select values that are consistent. If a concentration is found to be inconsistent by at least an order of magnitude, it is not used in this evaluation.

Newly constructed wells often exhibit concentrations of particulates and colloidal material for several sampling rounds. In some of the early sampling rounds, the unfiltered concentrations of inorganic analytes are often several orders of magnitude higher than the filtered results. In the later sampling rounds, the unfiltered concentrations tend to equilibrate to concentrations that are roughly equivalent to the filtered results. The equilibrated concentrations are considered, for the purposes of this risk assessment, representative of groundwater conditions. Additional discussion and information on the equilibration of the wells are provided in Appendix A of the 100-BC-5 LFI (DOE-RL 1993b).

A comparative analysis of late round data and the data from all five sampling rounds is included in the representative data analysis. The analysis concluded that the use of data from the last two rounds would serve to eliminate data that are not representative of groundwater conditions near the river (i.e., nonequilibrated data from the initial sampling rounds). Therefore, the groundwater concentrations from the last two rounds of LFI sampling data are selected for use in this evaluation because they are more representative of actual groundwater conditions than data from earlier sampling rounds that were affected by particulate and colloidal materials from the well installations.

Data from near-river wells are selected for use in this risk assessment because near-river data are likely the most representative of groundwater available for potential human exposures at the riverbank springs and the river. A comparative analysis of near-river data and entire operable unit data was included in the representative data analysis to verify that the use of the near-river data set does not preclude the evaluation of potentially greater exposures from inland groundwater locations. The conclusions of this analysis, provided in Appendix A, state that the groundwater concentrations inland of the near-river wells may be greater than the concentrations at near-river locations for some contaminants, but the results of the risk assessment would not be significantly affected by the variations in the data sets. Therefore, it is reasonable to assume that the near-river data are representative of groundwater conditions at the riverbank where potential human exposures may occur.

Maximum concentrations are typically used when receptors are exposed to contaminants at a single location. The use of an upper confidence limit (UCL) would be appropriate for exposures to contaminants in multiple locations (e.g., several drinking water wells) because the UCL characterizes (in part) the spatial distribution of contaminants. At the 100-BC-5 Operable Unit, the point of exposure is a single location (receptors potentially exposed to groundwater from a spring at the riverbank), therefore it is more appropriate to use the maximum concentration for this risk assessment. This method is conservative because it assumes a receptor is exposed to a maximum concentration of all contaminants, as if all of the maximum concentrations could be accessed at a single point location.

The mean of the maximum representative concentrations from the last two sampling rounds is calculated to provide the exposure point concentrations for each contaminant. The exposure point concentrations of contaminants selected for further evaluations are compared to background concentrations using Hanford Sitewide provisional threshold levels as the control data for the 100-BC-5 Operable Unit. Analytes with exposure point concentrations exceeding control concentrations are retained for preliminary risk-based screening.

The rationale for eliminating or retaining parameters for further evaluations is provided in Table B-1. Polychlorinated biphenyls and pesticides are not included in the table since they were not detected in any of the analyses. For brevity, organic compounds that have not been detected in the 100-BC-5 Operable Unit throughout the five LFI sampling rounds are not included in Table B-1.

The following are noted in the selection of contaminants:

Radionuclides

- Cesium-134, chromium-51, cobalt-60, europium-152, europium-154, iron-59, ruthenium-106, thorium-232, and zinc-65 are not detected in any wells in the entire 100-BC-5 Operable Unit over five sampling rounds and are eliminated from further evaluation.

- Americium-241, cesium-137, plutonium-238, plutonium-239/240, potassium-40, radium-226, and thorium-228 are detected at a detection rate of less than 5% for all wells in the entire operable unit over five sampling rounds and are eliminated from further evaluation.

- Carbon-14 is detected sporadically throughout the 100-BC-5 Operable Unit, however, it is not detected in a consistent manner at a single location over five sampling rounds. Since there are no representative detects of this parameter, it is eliminated from further evaluation.

- The summary maximum representative late round near-river concentrations of gross alpha and total uranium are less than the background concentrations for these parameters and they are eliminated from further evaluation.

- The summary maximum representative late round near-river gross beta concentration is greater than its corresponding background concentration; however, this is a non-specific indicator parameter and there are no toxicity data available for evaluation. Data are available, as appropriate, for specific beta emitters, therefore gross beta is eliminated from further evaluation.

- Strontium-90, technetium-99, and tritium are detected in late-round near-river data and are retained for preliminary risk-based screening.

Inorganic Analytes

- Antimony and cobalt are not detected in any wells in the entire 100-BC-5 Operable Unit over five sampling rounds and are eliminated from further evaluation.

- Beryllium, mercury, silver, thallium, and cyanide are detected at a detection rate of less than 5% in the entire operable unit over five sampling rounds and are eliminated from further evaluation.

- Arsenic and cadmium are not detected in any near-river wells at the 100-BC-5 Operable Unit over five sampling rounds and are eliminated from further evaluation.

- Copper, selenium, and zinc are detected inconsistently in near-river wells over five sampling rounds. Since there are no representative detections of these parameters in the near-river wells, they are eliminated from further evaluation.

- The summary maximum representative late round, near-river concentrations of barium, calcium, magnesium, manganese, potassium, sodium, and vanadium are less than the background concentrations for these parameters and they are eliminated from further evaluation.

- The summary maximum representative late round near-river concentrations of aluminum and iron are greater than their corresponding background concentration; however, these parameters are eliminated from further evaluations as recommended in HSRAM (DOE-RL 1994c) for contaminants that are essentially nontoxic under typical environmental exposure scenarios.

- Chromium, lead, and nickel are detected in late-round near-river data and are retained for preliminary risk-based screening.

Wet Chemistry and Anions

- Ammonia, chemical oxygen demand, hydrazine, and sulfide are not detected in late round near-river data for the 100-BC-5 Operable Unit and are eliminated from further evaluation.

- Phosphate is detected at less than a 5% detection rate for wells in the entire operable unit over five sampling rounds and is eliminated from further evaluation.

- Total organic halides are detected sporadically throughout the 100-BC-5 Operable Unit over five sampling rounds; therefore there are no representative detects of this parameter and it is eliminated from further evaluation.

- The summary maximum representative late round near-river concentrations for alkalinity, conductivity, fluoride, sulfate, and total organic carbon are less than the background concentrations for these parameters and they are eliminated from further evaluation.

- The maximum and minimum pH and maximum total dissolved solids results are outside of their corresponding background values; however, they are general water quality indicators, and are eliminated from further evaluation.

- Chloride and nitrate as N are detected in late-round near-river data and are retained for preliminary risk-based screening.

Organic Compounds

- Acetone, benzene, 2-butanone, chlorobenzene, chloroform, diethylphthalate, di-n-butylphthalate, di-n-octylphthalate, 2-hexanone, methylene chloride, 4-methyl-2-pentanone, and 1,1,2,2-tetrachloroethane are detected at less than a 5% detection rate for all wells in the entire operable unit over five sampling rounds and are eliminated from further evaluation.

- Bis(2-ethylhexyl)phthalate, toluene, and trichloroethene are detected in late-round near-river data and are retained for preliminary risk-based screening.

2.2 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

The initial list of contaminants with maximum representative concentrations above background is evaluated in a preliminary risk-based screening to identify the contaminants of potential concern. Risk-based screening concentrations are defined using contaminant-specific slope factors (SF), reference doses (RfD), residential exposure parameters, a lifetime ICR of 10^{-7}, and a HQ of 0.1, as defined in the HSRAM (DOE-RL 1994c).

Results of the preliminary risk-based screening are summarized in Table B-2. Detailed toxicity information for the contaminants of potential concern (including references for toxicity information presented on Table B-2) is presented on Tables B-3a and B-3b. The contaminants that pass the screening criteria are eliminated from further evaluation. The contaminants with summary maximum representative concentrations exceeding risk-based concentrations parameters (indicated by shading on the tables) are considered contaminants of potential concern for the 100-BC-5 Operable Unit and are retained for evaluation in the risk assessment. The COPC for the 100-BC-5 Operable Unit are as follows:

Radionuclides

Strontium-90
Technetium-99
Tritium

Inorganic Analytes

Chromium

Wet Chemistry and Anions

Nitrate as N

Organic Compounds

Bis(2-ethylhexyl)phthalate
Trichloroethene

There are no toxicity factors available to evaluate lead and chloride. Therefore, specific intakes and risks cannot be calculated for these parameters. Lead is considered a carcinogen, however, the concentration used in this evaluation (0.0079 mg/L) is an order of magnitude less than the primary maximum contaminant level (Washington Administrative Code [WAC] 173-200-040) and the human water quality health criterion (EPA 1986) for lead (both criteria are 0.05 mg/L). Chloride is not a carcinogen and is essentially nontoxic at low concentrations. The chloride concentration used in this evaluation (13.8 mg/L) is one order of magnitude less than the secondary maximum contaminant level of 250 mg/L (EPA 1986). Lead and chloride are not retained for further evaluation.

2.3 UNCERTAINTY IN THE IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN AND CONCENTRATIONS

The uncertainty in the identification of contaminants present in the groundwater is low. The LFI data available to identify contaminants in the groundwater are of known quality, are analyzed using EPA methods, and are validated prior to use. Five rounds of data have been evaluated for consistency and use in the risk assessment.

The uncertainty in the distribution of contaminants in the groundwater in the 100-BC-5 Operable Unit is low. The representative data analysis (Appendix A) concludes that concentrations inland from near-river wells occasionally have higher concentrations of some contaminants, however, the maximum concentrations of radionuclide contaminants, including strontium-90, are all located at the near-river portion of the 100-BC-5 Operable Unit.

There is uncertainty in the degree that contaminant concentrations potentially fluctuate due to groundwater recharge from the river. The Columbia River has highly variable flow levels based on power demands and seasonal changes. Consequently, groundwater flow varies into or away from the river, causing potential recharge to groundwater. It is unknown whether the groundwater data used in this risk assessment represent groundwater as it occurs within the 100-BC-5 Operable Unit, or groundwater that has been diluted by the river.

This risk assessment evaluates the contribution of contaminants from 100-BC-5 Operable Unit groundwater to riverbank springs and the river. However, there are only four wells within the proximity of the river available to provide groundwater data for the risk assessment; there are insufficient spring or river data available at the time of this evaluation to quantify the risks associated with surface water. There is uncertainty in the contribution of contaminants from groundwater to surface water and the levels of dilution when groundwater enters surface water.

Additional uncertainty exists in the assumption that radionuclide concentrations remain the same for the 30-year exposure period. For some radionuclides, radioactive decay over time can significantly reduce the concentrations to which a receptor may be exposed. For example, concentrations of strontium-90, the primary risk-driving contaminant, would be reduced to one-half of current concentrations in about 30 years.

3.0 HUMAN HEALTH EVALUATION

This section presents a summary of the exposure and toxicity assessment, the risk characterization, and uncertainty analysis for the 100-BC-5 operable unit. The methodology used in the risk assessment is presented in the HSRAM (DOE-RL 1994c).

3.1 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is to estimate the magnitude, frequency, duration, and route of exposure to the COPC that human receptors may experience. This exposure information is then integrated with appropriate toxicity information to provide an assessment of the nature and extent of any health threats from the COPC. The primary components of an exposure assessment are identification of potential human receptor populations and exposure pathways, exposure point concentrations, and the quantification of contaminants intakes. The scenarios and pathways for this risk assessment have been discussed and selected by the 100 Area Tri-Party unit managers.

3.1.1 Exposure Scenarios

The exposure scenarios evaluated in this risk assessment are based on realistic assumptions concerning current and future uses at this site, in compliance with the Hanford Future Site Uses Working Group (HFSUWG) recommendations. The HFSUWG recommended that the 100 Area be classified for unrestricted land use and listed four options for consideration (HFSUWG 1992). The options are: (1) Native American uses; (2) limited recreation, recreation-related commercial uses and wildlife; (3) B-reactor as a museum/visitor center; and (4) wildlife and recreation.

None of the HFSUWG options specifically identify the use of groundwater at the 100-BC-5 operable unit. There are currently no drinking water wells at the 100 B/C Area, thus there is no direct access to groundwater at the 100 B/C Area by humans. However, as shown in the LFI (DOE-RL 1993b), there is a potential for springs at the edge of the Columbia River, and the river itself, to be affected by groundwater from the 100-BC-5 Operable Unit. Site trespassers can gain access to the riverbank springs and have contact with the river.

The HFSUWG Native American and recreational options could include the use of spring and river waters, and therefore could be affected by impacts to 100-BC-5 Operable Unit groundwater. Therefore, the exposure scenario evaluated in this risk assessment, as agreed by the Tri-Party unit managers, is the use of springs and river water potentially affected by groundwater from the 100-BC-5 Operable Unit by recreational users (trespassers). For the purposes of this evaluation, Native American and recreational uses of 100-BC-5 Operable Unit groundwater are assumed to be equivalent. Additional discussion of this scenario is provided in the HSRAM (DOE-RL 1994c).

Environmental receptors that use riverbank springs and river water typically have ranges that extend beyond the river bank or area immediately adjacent to the groundwater discharge from the 100-BC-5 Operable Unit. Additionally, the Columbia River receives ground and surface water from many potentially contaminated sources. Therefore, an evaluation of the potential risks associated with the 100-BC-5 Operable Unit would only represent a portion of the total risks associated with most receptors using the riverbank and river and is deferred to the Columbia River Comprehensive Impact Assessment.

3.1.2 Exposure Pathways

The Tri-Party unit managers have agreed that reasonable exposure pathways associated with the selected exposure scenario are ingestion of spring or river water in the vicinity of the 100-BC-5 Operable Unit that is potentially affected by groundwater from the operable unit, and ingestion of fish from the Columbia River in the vicinity of the 100 B/C Area.

There are no 100-BC-5 Operable Unit-specific fish tissue data available in the vicinity of the 100-BC-5 Operable Unit. Therefore, the evaluation of risks associated with the ingestion of fish from the Columbia River is based on contaminant data from fish taken for general environmental monitoring in the Columbia River near the 100 Area (Bisping and Woodruff 1992). The fish ingestion evaluation is conducted only for the contaminants identified in the groundwater/springs evaluation that have an ICR $>10^{-6}$, or HQ greater than unity for water ingestion.

Inhalation exposures are not considered in this risk assessment because these exposures are typically related to the use of water in the home (EPA 1991) whereby volatilization occurs (such as dishwashers, bathrooms, showers, etc.). Since the selected exposure scenario does not include residential uses, inhalation of groundwater is not considered in this evaluation. This approach is consistent with HSRAM (DOE-RL 1994c).

Other exposure pathways are possible such as dermal absorption of contaminants during water use and exposure to radionuclides through submersion in water. Exposures from absorption of nonradioactive contaminants would not be as significant as exposures from ingestion because the contaminants of potential concern, in general, do not have high dermal permeabilities and the duration of exposure is generally shorter. For radionuclides, exposures that occur through water submersion are typically of less significance because of the shielding effects of water and the generally short duration of exposure (EPA 1989).

No other pathways are evaluated in this risk assessment. No modeling of contaminant transport or dilution in the river has been conducted in this risk assessment.

3.1.3 Quantification of Human Exposures

The exposure assessment quantifies exposures for the selected pathways. An exposure point concentration (i.e., a contaminants concentration to which a receptor is subjected over the exposure period) is estimated and used with exposure parameters (e.g., contact rate, body weight, and exposure frequency) to determine an intake. The exposure parameters and equations used in this risk assessment are defined in the HSRAM (DOE-RL 1994c). Recreational exposure parameters are used to evaluate potential human exposures to contaminants in the near-river groundwater from the 100-BC-5 Operable Unit. A summary of these parameters is provided in Table B-4.

For purposes of this risk assessment, the exposure point concentration is the mean of the maximum representative concentrations from the last two LFI sampling rounds for each contaminant of potential concern, as described in Section B-2.1 and shown on Table B-2. The methodology and equations for calculation of contaminant intakes (a measure of exposure expressed as the concentration that is contacted over a period of time) are standard EPA equations (EPA 1989) as presented in the HSRAM (DOE-RL 1994c). Example equations and calculations are also provided in the HSRAM (DOE-RL 1994c). The estimated intakes of contaminants of potential concern for the scenarios are presented in Table B-5. Intakes are provided for both non-carcinogenic and carcinogenic effects.

3.1.4 Uncertainty in the Exposure Assessment

The recreational scenario evaluated in this risk assessment (i.e., use of spring water routinely over a 30-year period) is not known to occur at the 100 B/C Area. The risk assessment is based on potential exposures to the maximum concentration, assuming that these will not increase or decrease over a 30-year lifetime exposure. Therefore, there is uncertainty in the results because of the use of a maximum concentration that may not be representative of long term exposures.

The exposure assessment focuses on only the ingestion of water from groundwater use. Exposure through other pathways such as external exposure from submersion in radionuclide-contaminated waste may result in additional risk, though it is not known if the additional risk would be significant. In general, for most inorganic constituents and radionuclides, exposure through the ingestion route is greater than for other routes of exposure to contaminants in water. For example, strontium-90, the primary risk-driving contaminant, is a relatively important ingestion hazard, but is not associated with an external exposure hazards since it has negligible gamma emissions.

The exposure assessment does not account for radioactive decay over time. For some radionuclides, radioactive decay can significantly reduce the concentrations to which a receptor may be exposed. For example, the exposure point concentration for strontium-90 would be reduced approximately one-half of the current concentration in thirty years (i.e., by the year 2018).

Exposure parameters (i.e., body weight, averaging time, contact rate, exposure frequency, and exposure duration) represent reasonable maximum values as defined in the HSRAM (DOE-RL 1994c), but may not reflect actual exposure conditions. For example, for carcinogenic parameters, the groundwater ingestion pathway uses the assumption that a recreational visitor consumes 2 L of groundwater from a riverbank spring 7 days a year for 30 yr. To assume that a person visits the same spring at the same operable unit for one week every year, however, may not be reasonable. Consequently, such exposure conditions are likely to contribute to an overestimation of risk.

Only contaminants exceeding the 10^{-6} risk level by ingestion are evaluated for fish ingestion. The remaining contaminants of potential concern do not bioconcentrate significantly and thus, it is unlikely that they would present hazards in this pathway.

There is uncertainty in the use of fish carcass data instead of fish muscle tissue data. Fish carcass data represent both ingested (fish muscle tissue) and non-ingested (organs, bones, etc.) portions of the fish, and as a result, may represent overestimates of contaminant concentrations typically available for exposure to humans.

3.2 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to identify the potential adverse effects associated with exposure to site-related contaminants and to evaluate, using numerical toxicity values, the likelihood that these adverse effects may occur. The general procedures for toxicity assessment are presented in the HSRAM (DOE-RL 1994c).

Toxicity profiles for all COPC at the Hanford Site are under development for a sitewide toxicity document and are not provided in this report. Summaries of the toxicity factors for the carcinogenic and noncarcinogenic contaminants identified for the 100-BC-5 Operable Unit are provided in Tables B-3a and B-3b, respectively. All chromium is assumed to be chromium (VI), which is generally the most toxic and soluble valence state of chromium. All nitrate/nitrite values are converted to nitrate as N, and it is assumed that the nitrite contribution to the nitrate/nitrite value is negligible.

3.2.1 Uncertainty in the Toxicity Assessment

The RfD and SF have multiple conservative calculations built into them (i.e., factors of 10 for up to four different levels of uncertainty for RfD, and the use of an upperbound estimate derived from the linearized multistage carcinogenic model for SF) that can contribute to overestimation of actual risk. The extrapolation of data from high-dose animal studies to low-dose human exposures may overestimate the risk in the human population because of metabolic differences, repair mechanisms, or differential susceptibility. It is also possible that such an extrapolation could underestimate the risk to humans. However, the use of uncertainty factors, modifying factors, and upper bound estimates in the development of toxicity values is intended to compensate for this uncertainty.

The carcinogenic COPC are all known human carcinogens (Class A), except bis(2-ethylhexyl)phthalate (B2 probable human carcinogen) and trichloroethene (currently under review as a Class C or B2). Chromium is a Class A carcinogen by inhalation only. Nitrate is not classified as a carcinogen.

The confidence in the RfD ranges from low to high, with low confidence assigned to the RfD for chromium VI and trichloroethene. The critical effects vary from changes in liver weight to blood effects. Therefore, different systemic toxicity hazards are evaluated in this risk assessment.

3.3 RISK CHARACTERIZATION

The risk characterization for this risk assessment is conducted as presented in the HSRAM (DOE-RL 1994c) based on the information from the exposure assessment and toxicity assessment. It forms the basis for characterizing risks and human health hazards from potential exposures to COPC detected at the 100-BC-5 Operable Unit.

The pathways evaluated in the risk characterization are ingestion of water and ingestion of fish by recreational users. Other pathways that have not been quantitatively evaluated include dermal exposure to contaminants in the groundwater or external exposure occurring from submersion in radionuclide contaminated water. Consequently, the overall risk estimates do not include a contribution from these pathways. In general, these pathways would not contribute significantly to the overall risk when compared to the ingestion pathway because of the low dermal permeabilities for the COPC and the short duration of exposures for dermal or submersion.

3.3.1 Quantification of Carcinogenic Risk

For carcinogens, risks are estimates of the likelihood of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen (i.e., lifetime ICR). The SF converts an intake value, as derived in the exposure assessment, to the estimated lifetime incremental risk of an individual developing cancer. The equation used to estimate cancer risk is:

$$ICR = (Intake) \times (SF)$$

For nonradioactive carcinogens, intake values represent a daily intake averaged over a lifetime of exposure. Slope factors for chemical carcinogens generally represent a 95% upper confidence limit of the slope of the dose-response curve. Thus, one can be reasonably confident that the actual risk is likely to be less than that predicted. The ICR should be expressed using one significant figure only.

Intake values for radionuclides are defined to represent lifetime (not daily) exposures. Unlike most chemical slope factors, slope factors for radionuclides are generally best estimate, or 50% confidence limit, values.

The NCP (40 CFR 300.430(e)(2)(i)(A)(2)) states that acceptable exposure levels represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}. The 10^{-6} risk level is considered a point of departure for determining remediation goals when ARAR are not available or are not considered sufficiently protective. Thus, cancer risks of 10^{-6} or less are generally considered insignificant for regulatory purposes.

Table B-5 presents the results of the risk characterization for all carcinogenic contaminants of potential concern. All ICR exceeding 10^{-6} are indicated by shading on this table. The total ICR for the 100-BC-5 Operable Unit is 2×10^{-6}, attributable primarily to strontium-90. No other carcinogenic contaminants exceed an ICR of 10^{-6}.

The risks associated with ingestion of fish from the Columbia River are included for all contaminants with an ICR exceeding 10^{-6} (strontium-90) to determine potential added risks associated with the ingestion of fish caught in the 100 Area of the Columbia River. The intakes and risks (ICR) associated with the ingestion of fish (using carcasses as surrogate fish concentration data) are presented in Table B-6. The ICR for the ingestion of whitefish, carp, and bass are all an order of magnitude less than 10^{-6}.

3.3.2 Quantification of Non-Carcinogenic Effects

Potential human health hazards associated with exposure to noncarcinogenic substances, or carcinogenic substances with systemic toxicities other than cancer, are evaluated separately from carcinogenic risks. The daily intake over a specified time period (e.g., lifetime or some shorter time period) is compared with a chronic RfD to determine the HQ. The formula used to estimate the HQ is:

$$HQ = \frac{\text{Chronic Daily Intake}}{RfD}$$

If the HQ exceeds unity, the possibility exists for systemic toxic effects. The HQ is not a mathematical prediction of the severity or incidence of the effects, but rather is an indication that adverse effects may occur, especially in sensitive subpopulations.

Table B-5 presents the results of the risk characterization for all noncarcinogenic COPC. All HQ or HI greater than unity are shaded in this table. The HI for the 100-BC-5 Operable Unit is estimated to be less than unity, at a value of 0.012. All noncarcinogenic contaminants have individual HQ that are at least two orders of magnitude less than unity.

Since there are no HQ that exceed unity for noncarcinogenic contaminants in the water ingestion pathway, there is no evaluation of fish ingestion for noncarcinogenic contaminants.

3.3.3 Uncertainty in the Risk Characterization

Hazard quotients and risk values provided by risk assessment by themselves do not fully characterize the health impacts associated with environmental contamination. Such a quantitative evaluation must be understood in light of the uncertainties presented above, and interpreted with respect to their significance.

Hazard quotients and cancer risks are calculated by multiplying multiple factors (e.g., contaminant concentrations, exposure parameters, toxicity values). In an effort to compensate for the uncertainty and/or natural variability in these factors, single point estimates used to characterize these factors are often conservatively biased. However, even if this bias for each factor can be considered reasonable, the product of these factors is likely to far exceed a reasonable maximum exposure. This means that the risk estimates presented in a deterministic risk assessment are representative of a set of assumptions that, as a group, is extremely unlikely. Use of a more realistic set of assumptions is likely to yield significantly lower risk estimates.

The significance of numerical results requires interpretation. In presenting the quantification of carcinogenic risk, contaminants and pathways are described if their associated ICR exceed 10^{-6}. Although a 10^{-6} cancer risk may be considered insignificant, this does not imply that larger risks are necessarily significant. The NCP (40 CFR 300.430(e)(2)(i)(A)(2)) states that acceptable exposure levels represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}.

4.0 SUMMARY AND CONCLUSIONS

This risk assessment evaluates the human health risks posed by contaminants in the 100-BC-5 Operable Unit under one exposure scenario (recreational) and two exposure pathways (groundwater ingestion and fish ingestion) under current conditions. There is currently no use of groundwater at the 100-BC-5 Operable Unit, however, there is a potential for ingestion of surface water from springs and the Columbia River that may be affected by 100-BC-5 Operable Unit groundwater. Due to insufficient spring and river data, data from the last two rounds (Spring and Fall 1993) of LFI groundwater sampling from near-river wells are used to evaluate the concentrations of contaminants in the springs potentially available for human ingestion. No modeling of contaminant transport or dilution in the river has been conducted in this risk assessment.

At the writing of this report, plans are under development to address sources of 100-BC-5 Operable Unit groundwater contamination at the 100 B/C Area source operable units. It is assumed that once the sources of groundwater contamination are addressed, groundwater contaminant concentrations, and associated risks, would subsequently decrease. Therefore, future conditions are not addressed in this evaluation since the associated potential risks are likely to be lower than those associated with current conditions.

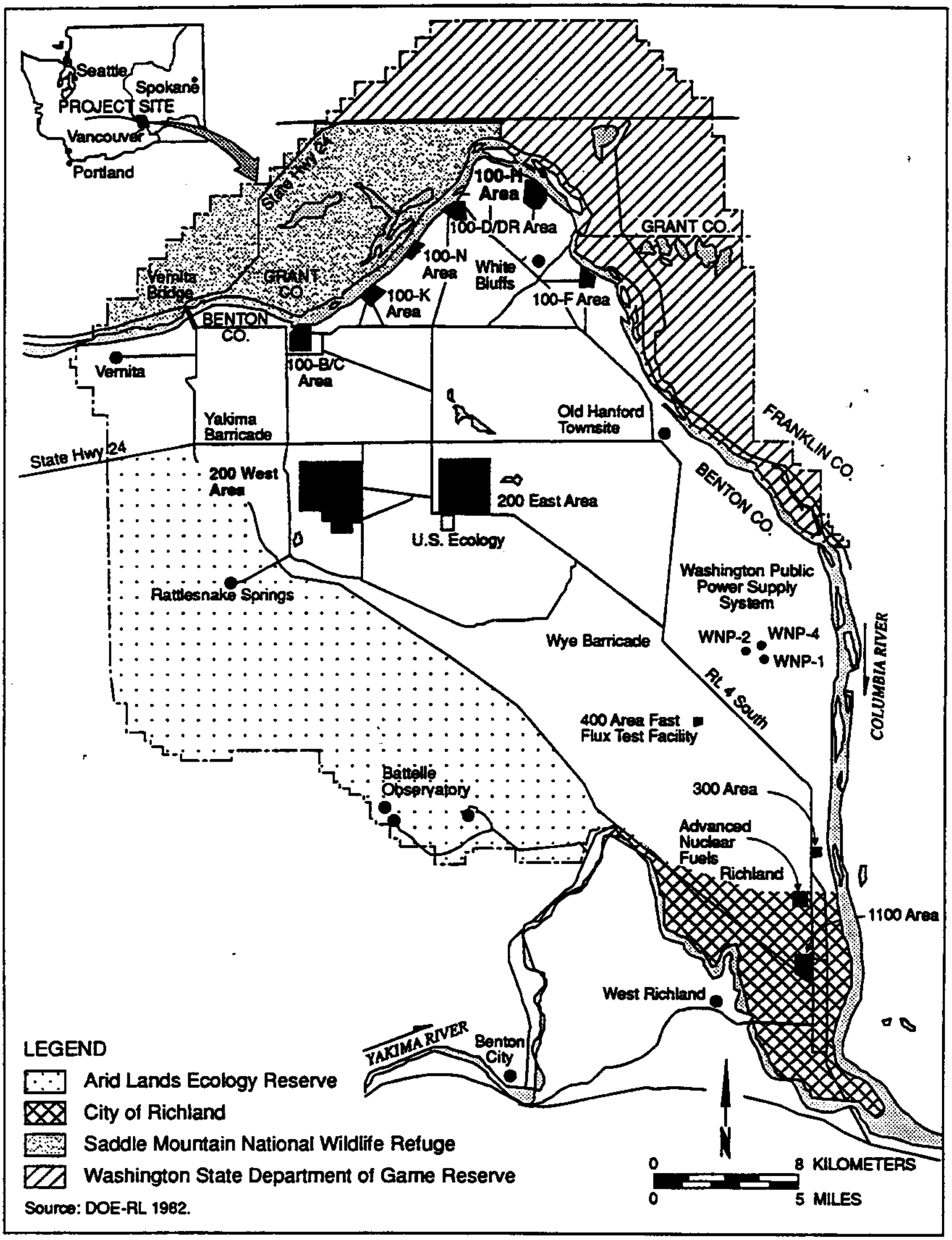
The ICR associated with COPC at the 100-BC-5 Operable Unit is $2x10^{-6}$ in the water ingestion pathway (see Table B-5). This ICR is primarily attributable to strontium-90. The ICR for all other carcinogenic contaminants are at least an order of magnitude $<10^{-6}$.

The total HI for the 100-BC-5 Operable Unit is 0.012 for groundwater ingestion (see Table B-5). Since this value is two orders of magnitude less than unity, no systemic toxic effects are expected to occur as a result of exposure to contaminants at the 100-BC-5 Operable Unit.

The intakes and risks associated with the ingestion of fish are calculated for strontium-90. The ICR (see Table B-6) associated with the ingestion of fish are all estimated to be less than 10^{-6}.

Uncertainty in the parameters used to perform the risk assessment for the 100-BC-5 Operable Unit was discussed in detail for identification of COC and their concentrations, the exposure assessment, the toxicity assessment, and the risk characterization. To avoid underestimation of these factors and account for natural variability, the single point estimates used to characterize these factors are conservatively biased. Multiplication of these factors to obtain ICR and HQ results in overestimation of the risk to human health.

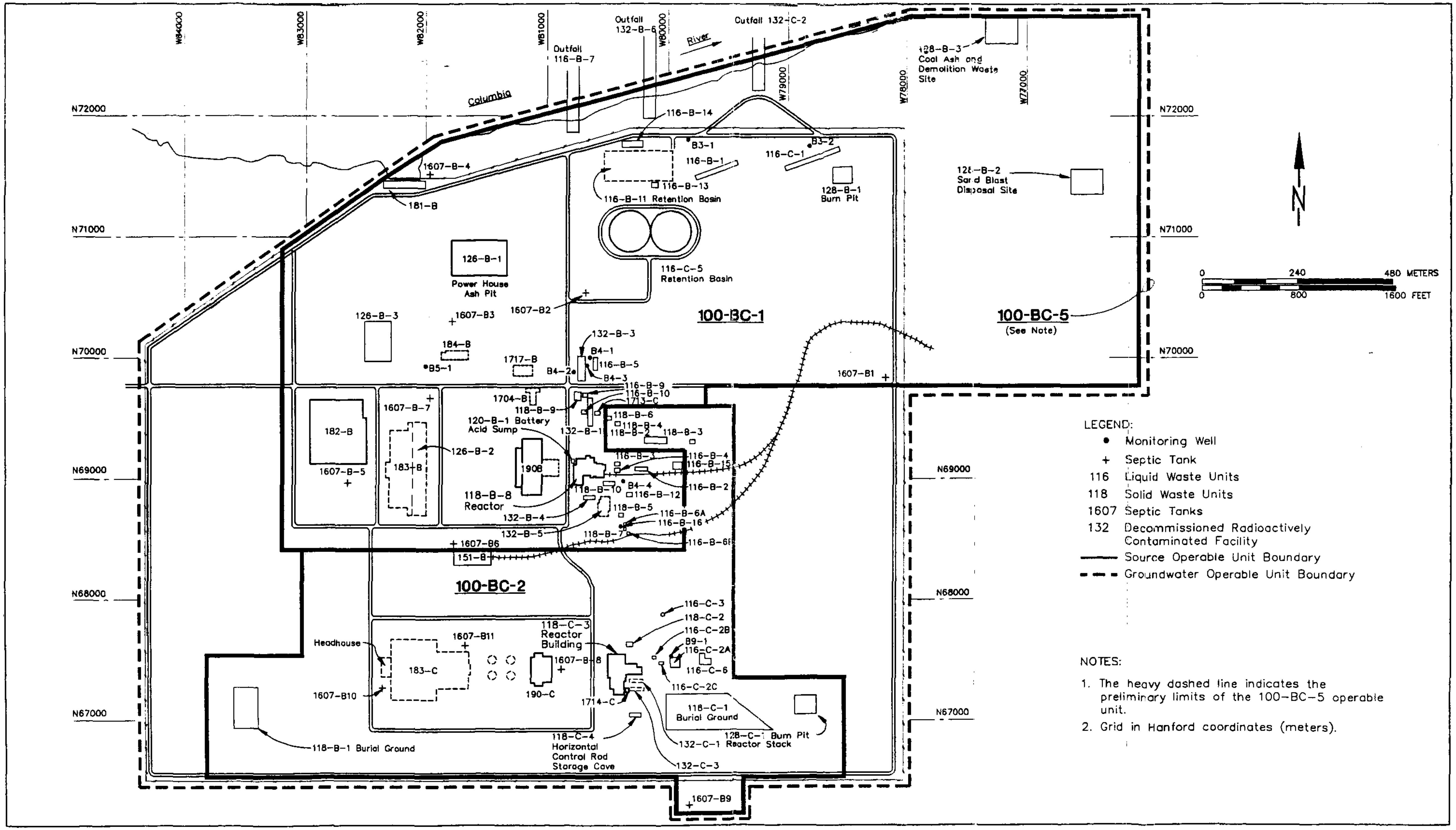
Figure B-1 Location of 100 B/C Area at the Hanford Site



923 E009/41417/6-28-94

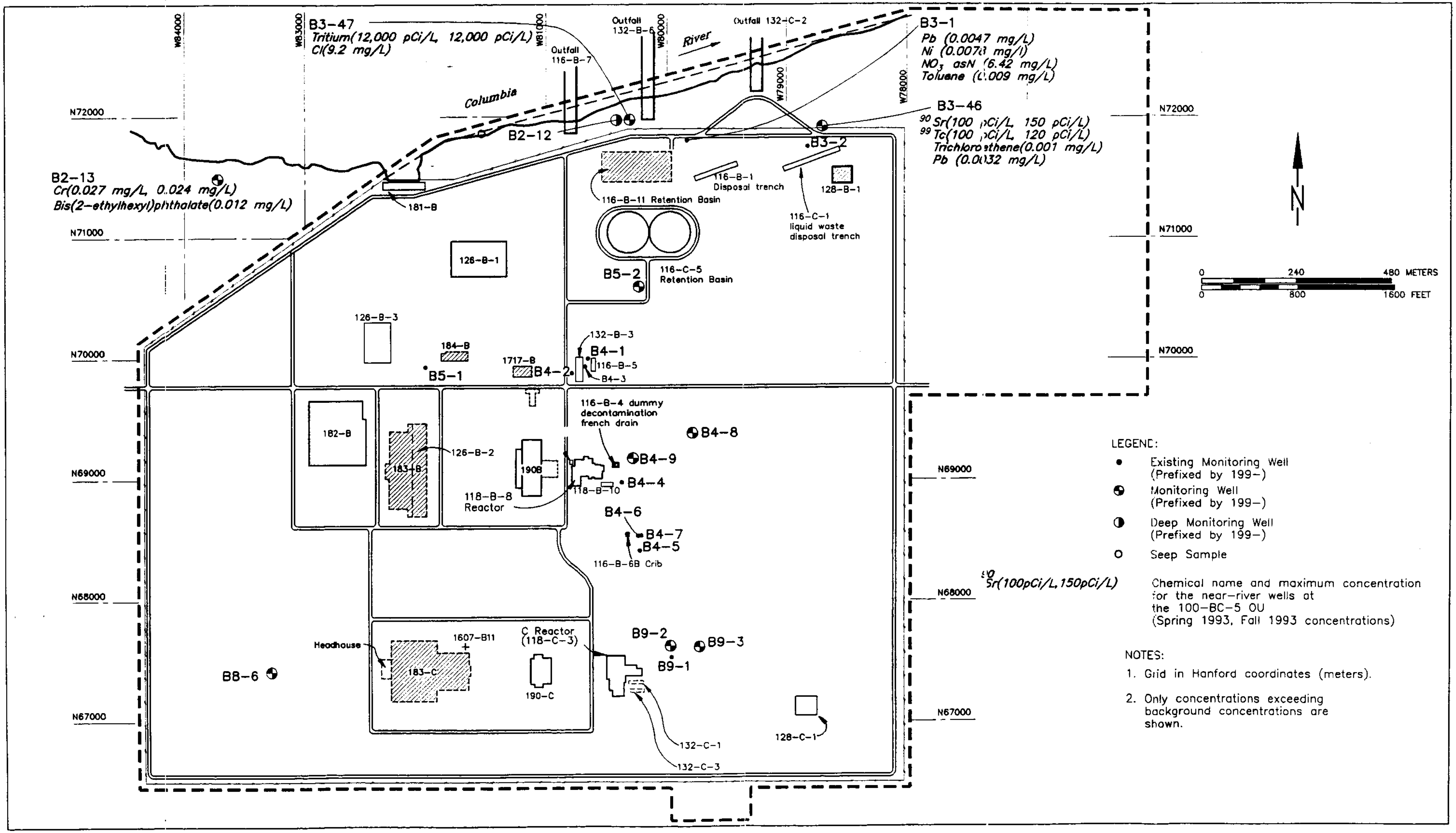
THIS PAGE INTENTIONALLY
LEFT BLANK

Figure B-2 Map of the 100 B/C Area Showing the Source and Groundwater Operable Units



THIS PAGE INTENTIONALLY
LEFT BLANK

Figure B-3 Approximate Locations of Monitoring Wells and Spatial Distribution of Contaminant Maximum Concentrations for the Near-River Wells



THIS PAGE INTENTIONALLY
LEFT BLANK

Table B-1 Summary of Data Selection for the 100-BC-5 Operable Unit (page 1 of 2)

Parameter	Units	Description of Selected Data	Maximum Representative Concentration	Provisional Background Concentration[a]	Rationale for Elimination
RADIONUCLIDES					
Americium-241	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Carbon-14	pCi/L	No representative detects in LRNR	ND	NV	No representative detects
Cesium-134	pCi/L	No detects in OU	ND	NV	Not detected
Cesium-137	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Chromium-51	pCi/L	No detects in OU	ND	NV	Not detected
Cobalt-60	pCi/L	No detects in OU	ND	NV	Not detected
Europium-152	pCi/L	No detects in OU	ND	NV	Not detected
Europium-154	pCi/L	No detects in OU	ND	NV	Not detected
Gross Alpha	pCi/L	Average of maximum values reported in OU	10	63	Less than background
Gross Beta	pCi/L	Average of maximum values reported in LRNR	245	35.5	Non-specific parameter
Iron-59	pCi/L	No detects in OU	ND	NV	Not detected
Plutonium-238	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Plutonium-239/240	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Potassium-40	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Radium-226	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Ruthenium-106	pCi/L	No detects in OU	ND	NV	Not detected
Strontium-90	pCi/L	Average of maximum values reported in OU	125	NV	Retained
Technetium-99	pCi/L	Average of maximum values reported in LRNR	110	NV	Retained
Thorium-228	pCi/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Thorium-232	pCi/L	No detects in OU	ND	NV	Not detected
Tritium	pCi/L	Average of maximum values reported in LRNR	12000	NV	Retained
Uranium (Total)	pCi/L	Average of maximum values reported in OU	2.2	3.43	Less than background
Zinc-65	pCi/L	No detects in OU	ND	NV	Not detected
INORGANIC CONSTITUENTS					
Aluminum	mg/L	Average of maximum values reported in OU	0.65	ND (0.20)	Eliminated per HSRAM (1994)
Antimony	mg/L	No detects in OU	ND	NV	Not detected
Arsenic	mg/L	No detects in NR	ND	0.01	Not detected
Barium	mg/L	Average of maximum values reported in OU	0.048	0.0685	Less than background
Beryllium	mg/L	Less than 5% detection rate in OU	ND	ND (0.005)	<5% detection rate
Cadmium	mg/L	No detects in NR	ND	ND (0.010)	Not detected
Calcium	mg/L	Average of maximum values reported in NR	52.8	63.6	Less than background
Chromium	mg/L	Average of maximum values reported in LRNR	0.0254	ND (0.030)	Retained
Cobalt	mg/L	No detects in OU	ND	NV	Not detected
Copper	mg/L	No representative detects in NR	ND	ND (0.030)	Not detected
Iron	mg/L	Average of maximum values reported in OU	0.90	0.086	Eliminated per HSRAM (1994)
Lead	mg/L	Average of maximum representative values in NR	0.0040	ND (0.005)	Retained
Magnesium	mg/L	Average of maximum values reported in LRNR	9.67	16.48	Less than background
Manganese	mg/L	Average of maximum representative values in OU	0.0068	0.0245	Less than background
Mercury	mg/L	Less than 5% detection rate in OU	ND	ND (0.0001)	<5% detection rate
Nickel	mg/L	Average of maximum representative values in NR	0.0078	ND (0.030)	Retained
Potassium	mg/L	Average of maximum values reported in LRNR	4.09	7.975	Less than background
Selenium	mg/L	No representative detects in OU	ND	ND (0.005)	No representative detects
Silver	mg/L	Less than 5% detection rate in OU	ND	ND (0.010)	<5% detection rate
Sodium	mg/L	Average of maximum values reported in OU	14.0	33.5	Less than background

THIS PAGE INTENTIONALLY
LEFT BLANK

Table B-1 Summary of Data Selection for the 100-BC-5 Operable Unit (page 2 of 2)

Parameter	Units	Description of Selected Data	Maximum Representative Concentration	Provisional Background Concentration[a]	Rationale for Elimination
Thallium	mg/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
Vanadium	mg/L	Average of maximum values reported in NR	0.0088	0.015	Less than background
Zinc	mg/L	No representative detects in NR	ND	ND (0.050)	Not detected
Cyanide	mg/L	Less than 5% detection rate in OU	ND	NV	<5% detection rate
WET CHEMISTRY AND ANIONS					
Alkalinity	mg/L	Average of maximum values reported in NR	112	210	Less than background
Ammonia as N	mg/L	No detects in LRNR	ND	NV	Not detected
Chemical Oxygen Demand	mg/L	No detects in LRNR	ND	NV	Not detected
Chloride	mg/L	Average of maximum values reported in LRNR	9.2	8.69	Retained
Conductivity	µmhos/cm[2]	Average of maximum values reported in NR	421	530	Less than background
Fluoride	mg/L	Average of maximum values reported in LRNR	0.3	0.775	Less than background
Hydrazine	mg/L	No detects in OU	ND	NV	Not detected
Nitrate as N	mg/L	Average of maximum values reported in LRNR	6.42	2.8	Retained
pH	std units	Minimum, maximum values reported in LRNR	7.9-8.1	7.3-8.3	Not toxic
Phosphate	mg/L	Less than 5% detection rate in OU	ND	ND (1.0)	<5% detection rate
Sulfate	mg/L	Average of maximum values reported in LRNR	50	90.5	Less than background
Sulfide	mg/L	No detects in LRNR	ND	NV	Not detected
Total Dissolved Solids	mg/L	Average of maximum values reported in NR	261	NV	Not toxic
Total Organic Carbon	mg/L	Average of maximum values reported in LRNR	0.62	2.61	Less than background
Total Organic Halides	mg/L	No representative detects in OU	ND	0.0376	No representative detects
ORGANIC COMPOUNDS (detected only)					
Acetone	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Benzene	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Bis(2-ethylhexyl)phthalate	mg/L	Average of maximum values reported in LRNR	0.012	NA	Retained
2-Butanone	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Chlorobenzene	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Chloroform	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Diethylphthalate	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Di-n-butylphthalate	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Di-n-octylphthalate	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
2-Hexanone	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Methylene chloride	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
4-Methyl-2-pentanone	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
1,1,2,2-Tetrachloroethane	mg/L	Less than 5% detection rate in OU	ND	NA	<5% detection rate
Toluene	mg/L	Average of maximum values reported in OU	0.009	NA	Retained
Trichloroethene	mg/L	Average of maximum values reported in LRNR	0.001	NA	Retained

Note: Shaded areas indicate parameter retained for further evaluation
[a] From Hanford Site Groundwater Background (DOE-RL 1992b)
OU = Operable Unit
NR = Near-River portion of the 100-BC-5 Operable Unit
LRNR = Late Round Data (fourth and fifth rounds) for Near-River portion of the 100-BC-5 Operable Unit
ND = Not detected, detection limit is given in parentheses for parameters not detected in provisional background samples
NV = No value given
NA = Not applicable

Table B-2 Summary of the Preliminary Risk-Based Screening for the 100-BC-5 Operable Unit

Parameter	Maximum Representative Concentration	Oral RfD (mg/kg-d)	Groundwater Concentration at Oral HQ=0.1	Oral Slope Factor	Groundwater Concentration at Oral ICR=1E-07
RADIONUCLIDES	pCi/L			$(pCi)^{-1}$	
Strontium-90	125	--	--	3.6E-11	0.13
Technetium-99	110	--	--	1.3E-12	3.5
Tritium	12000	--	--	5.4E-14	85
INORGANIC CONSTITUENTS	(mg/L)			$(mg/kg\text{-}d)^{-1}$	
Chromium	0.0254	5.0E-03	0.008	--[a]	--[a]
Lead	0.0040	ND	ND	ND	ND
Nickel	0.0078	2.0E-02	0.032	--[a]	--[a]
WET CHEMISTRY AND ANIONS	(mg/L)			$(mg/kg\text{-}d)^{-1}$	
Chloride	9.2	--	--	--[a]	--[a]
Nitrate as N	6.42	1.6E+00	2.6	--[a]	--[a]
ORGANIC COMPOUNDS	(mg/L)			$(mg/kg\text{-}d)^{-1}$	
Bis(2-ethylhexyl)phthalate	0.012	2.0E-02	0.032	1.4E-02	5.9E-04
Toluene	0.009	2.0E-01	0.32	--[a]	--[a]
Trichloroethene	0.001	6.0E-03	0.0096	1.1E-02	7.5E-04

Note: Shading indicates criterion exceeded, parameter retained as a contaminant of potential concern for further evaluation
-- = Not evaluated in this category
[a] Not carcinogenic by this exposure pathway
HQ - hazard quotient
RfD - Reference Dose
ICR - incremental cancer risk
ND - not detected

Table B-3a Summary of Carcinogenic Toxicity Information for Contaminants of Potential Concern at the 100-BC-5 Operable Unit

Contaminant	Weight of Evidence Classification	Type of Cancer	Oral SF $(pCi)^{-1}$	Inhalation SF $(pCi)^{-1}$	External SF $(pCi\text{-}yr/g)^{-1}$	Half-life (years)
RADIONUCLIDES						
Strontium-90	A	-	3.6E-11[a]	6.2E-11[a]	-[b]	2.9E+01
Technetium-99	A	-	1.3E-12[a]	8.3E-12[a]	6.0E-13[a]	2.1E+05
Tritium (H-3)	A	-	5.4E-14[a]	7.8E-14[a]	-[b]	1.2E+01
INORGANIC PARAMETERS						
Chromium (as VI)	A	lung	-[c]	4.2E+01[d]	NA	NA
Nitrate[f]	-	-	NA	NA	NA	NA
ORGANIC COMPOUNDS						
Bis(2-ethylhexyl)phthalate	B2	liver	1.4E-02[d]	ND	NA	NA
Trichloroethene	C-B2	-	1.1E-02[e]	6.0E-03[d]	NA	NA

a Health Effects Assessment Summary Tables (HEAST) (EPA 1993a).
b Not an external exposure hazard.
c Not considered carcinogenic through this exposure pathway.
d Integrated Risk Information System (EPA 1994)
e Superfund Technical Support Center (EPA 1993b)
f Not classified as a carcinogen (EPA 1994)
NA = Not Applicable
SF = Slope factor
- Not determined
Note: Radionuclide slope factors account for the contribution of radioactive daughter products, as indicated in HEAST (EPA 1993a).

Table B-3b Summary of Systemic Toxicity Information for Contaminants of Potential Concern at the 100-BC-5 Operable Unit

Contaminant	Oral RfD mg/kg-d	Oral RfD[a,b] (basis/source)	Confidence Level	Critical Effect	Uncertainty Factors	Modifying Factors	Inhalation RfD mg/kg-d	Inhalation RfD[a,b] (basis/source)	Confidence Level	Critical Effect	Uncertainty Factors	Modifying Factors
INORGANICS												
Chromium (VI)	5.0E-03	water/IRIS	L	none observed	500	1	ND	--	--	--	--	--
Lead	ND	--	--	--	--	--	ND	--	--	--	--	--
Nickel	2.0E-02	food/IRIS	M	decreased body, organ weight	300	1	ND	--	--	--	--	--
Nitrate (as Nitrogen)	1.6E+00	water/IRIS	H	methemo-globinemia	1	1	ND	--	--	--	--	--
ORGANICs												
Bis-2(ethylhexyl)phthalate	2.0E-02	oral/IRIS	M	increased liver weight	1000	1	ND	--	--	--	--	--
Toluene	2.0E-01	gavage/IRIS	M	changes in liver and kidney weights	1000	1	1.0E-01	air/IRIS	M	neurological effects	300	1
Trichloroethene	6.0E-03	-/STSC[c]	L	--	3000	1	ND	--	--	--	--	--

[a] Integrated Risk Information System (EPA 1994).
[b] Health Effects Assessment Summary Tables (EPA 1993a).
[c] Superfund Technical Support Center (EPA 1992).
L = Low.
M = Medium.
H = High.
RfD = Reference Dose.
ND = Not determined.
-- = Not applicable.

Table B-4 Summary of Recreational Exposure Parameters

Pathway	Daily Intake Rate	Exposure Frequency	Exposure Duration	Body Weight	Averaging Time	Time Conversion Factor	Consumption Factor	Mass Conversion Factor	Summary Intake Factor
Noncarcinogens									
Groundwater Ingestion	1 L/day	7 day/yr	6 yr	16 kg	6 yr	365 day/yr	--	--	1.2E-03
Fish Ingestion	54 g/day	365 d/yr	30 yr	70 kg	30 yr	365 day/tr	0.5	0.001 kg/g	3.9E-04
Nonradioactive Carcinogens									
Groundwater Ingestion	2 L/day	7 day/yr	30 yr	70 kg	70 yr	365 day/yr	--	--	2.3E-04
Fish Ingestion	54 g/day	365 d/yr	30 yr	70 kg	70 yr	365 day/tr	0.5	0.001 kg/g	1.7E-04
Radionuclides									
Groundwater Ingestion	2 L/day	7 day/yr	30 yr	--	--	--	--	--	4.2E+02
Fish Ingestion	54 g/day	365 d/yr	30 yr	--	--	--	0.5	--	3.0E+05
From HSRAM (DOE-RL 1994)									

Table B-5 Summary of the Risk Assessment for the 100-BC-5-Operable Unit

Scenario - Recreational
Pathway - Water Ingestion

Carcinogenic Parameters		
Parameter	Intake mg/kg-d	ICR
RADIONUCLIDES		
Strontium-90	5.3E+04	2E-06
Technetium-99	4.6E+04	6E-08
Tritium	5.1E+06	3E-07
ORGANIC COMPOUNDS		
Bis(2-ethylhexyl)phthalate	2.8E-06	4E-08
Trichloroethene	2.3E-07	3E-09
TOTAL ICR		2E-06
Note: Shading indicates criterion exceeded		

Noncarcinogenic Parameters		
Parameter	Intake mg/kg-d	HQ
INORGANIC CONSTITUENTS		
Chromium	0.000031	0.006
WET CHEMISTRY AND ANIONS		
Nitrate as N	0.0078	0.005
ORGANIC COMPOUNDS		
Bis(2-ethylhexyl)phthalate	0.000015	0.0007
Trichloroethene	0.0000012	0.0002
TOTAL HI		0.01
Note: Shading indicates criterion exceeded ICR - incremental cancer risk		

Table B-6 Columbia River Fish Concentrations, Intakes, and Risk Summary

Fish	Source Area	Concentration pCi/g[a]	Intake pCi	ICR
Whitefish-carcass	100 N	3.2E-02	9.5E+03	3E-07
Carp-carcass	100 N	1.1E-02	3.4E+03	1E-07
Bass-carcass	100 F	3.0E-02	8.8E+03	3E-07

Note: Shading indicates criterion exceeded
a From *Hanford Site Environmental Data for Calendar Year 1992* (Bisping and Woodruff 1992).

APPENDIX C

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Table C-1 Potential Federal Chemical-Specific ARAR
(Page 1 of 2)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Safe Drinking Water Act	42 U.S.C. 300f et seq.		Creates a comprehensive national framework to ensure the quality and safety of drinking water.		
National Primary Drinking Water Regulations	40 CFR Part 141	R&A	Establishes maximum contaminant levels (MCL) and maximum contaminant level goals (MCLG) for organic, inorganic, and radioactive constituents. The MCL for combined radium-226 and radium-228 is 5 pCi/L. The MCL for gross alpha particle activity (including radium-226 but excluding radon and uranium) is 15 pCi/L. The average annual concentration of beta particle and photon radioactivity from manmade radionuclides in drinking water shall not produce an annual dose equivalent to total body or any internal organ in excess of 4 millirem/year. µg/L chromium 100 pCi/L strontium-90 8	Applicable to public water systems. Potential chemicals and radionuclides of concern may migrate to the drinking water supply as a result of remedial activities. Although federal MCLGs are not enforceable standards, they are potential ARARs under the Washington State Model Toxics Control Act when more stringent than other standards. See state ARARs.	All
National Secondary Drinking Water Regulations	40 CFR Part 143	R&A	Controls contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water. µg/L aluminum 50-200	Although federal secondary drinking water standards are not enforceable, they are potential ARARs under the Washington State Model Toxics Control Act when more stringent than other standards. See state ARARs.	All
Ambient Water Quality Criteria		A	Sets acute and chronic constituent concentrations for the protection of surface waters. Chromium (chronic) 11 µg/L Chromium (acute) 16 µg/L		All

Table C-1 Potential Federal Chemical-Specific ARAR

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA)	42 U.S.C. 6901 et seq.		Establishes the basic framework for federal regulation of solid and hazardous waste.		
Groundwater Protection Standards	40 CFR §264.92 [WAC 173-303-645][1]	A	A facility shall not contaminate the uppermost aquifer underlying the waste management area beyond the point of compliance, which is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated area. The concentration of certain chemicals shall not exceed background levels, certain specified maximum concentrations, or alternate concentration limits, whichever is higher. chromium — $\mu g/l$ 50	Groundwater concentration limits in this section do not exceed 40 CFR 141, except for chromium which has a limit of 50 $\mu g/L$.	GW-4, GW-5, GW-6,

*NOTE: A = Applicable, R&A = Relevant and Appropriate

[1]These are State of Washington regulatory citations which are equivalent to Title 40 Code of Federal Regulations, Parts 264 and 268 as stated in Washington Administrative Code 173-303.

Table C-2 Potential State Chemical-Specific ARAR
(Page 1 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Model Toxics Control Act (MTCA)	70.105D RCW		Requires remedial actions to attain a degree of cleanup protective of human health and the environment.		
Cleanup Regulations	WAC 173-340		Establishes cleanup levels and prescribes methods to calculate cleanup levels for soils, groundwater, surface water, and air.		
Groundwater Cleanup Standards	WAC 173-340-720	A	Requires that where the groundwater is a potential source of drinking water, cleanup levels under Method B must be at least as stringent as concentrations established under applicable state and federal laws, including the following: (A) MCL established under the Safe Drinking Water Act and published in 40 CFR 141, as amended; (B) MCLG for noncarcinogens established under the Safe Drinking Water Act and published in 40 CFR 141, as amended; (C) Secondary MCL established under the Safe Drinking Water Act and published in 40 CFR 143, as amended; as established by the state board of health and published in Chapter 248-54 WAC, as amended.	Federal MCLG for drinking water (40 CFR Part 141) and federal secondary drinking water regulation standards (40 CFR Part 143) are potential ARARs under MTCA when they are more stringent than other standards. Method B cleanup levels are levels applicable to remediation at Hanford unless a demonstration can be made that method C (alternate cleanup levels) is valid. Method B μg/l July 1993 update tables chromium VI 80	All
Surface Water Cleanup Standards	WAC 173-340-730	A	Requires surface water cleanup levels to be based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions.	MTCA method B values from the July 9, 1993 MTCA Cleanup Standards Database: Chromium (VI) 80 μg/L	All

Table C-2 Potential State Chemical-Specific ARAR

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Water Pollution Control	90.48 RCW				
Surface Water Quality Standards	WAC 173-201A		Sets surface water quality standards for the state.		
General Water Use and Criteria Classes	WAC 173-201A-030	A	Standards for surface water designated "Class A" include: freshwater temperature shall not exceed 18.0°C due to human activities. Temperature increases shall not at any time exceed t = 28/T+7 where "t" represents the maximum permissible temperature increase measured at a dilution zone boundary and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge. When natural conditions exceed 18.0° (freshwater) and 16.0° (marine water), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C. Provided that temperature increase resulting from nonpoint source activities shall not exceed 2.8°C, and the maximum water temperature shall not exceed 18.3°C (freshwater). pH shall be within the range of 6.5 to 8.5 (freshwater) with a man-caused variation within a range of less than 0.5 units.	The Hanford reach of the Columbia River is classified "Class A."	GW-5, GW-6
Toxic Substances	WAC 173-201A-040	A	Sets surface water limits for toxic substances. Freshwater limits in micrograms per liter for 100 Area contaminants are: (acute) (chronic) Chromium 16.0[a] 11.0[b] [a]A one-hour average concentration not to be exceeded more than once every three years. [b]A four-day average concentration not to be exceeded more than once every three years.		All

Table C-2 Potential State Chemical-Specific ARAR
(Page 3 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Radiation Protection -- Air Emissions	WAC 246-247		Establishes procedures for monitoring, control, and reporting of airborne radionuclide emissions.		
New and Modified Sources	WAC 246-247-070	A	Requires the use of best available radionuclide control technology (BARCT).		All
Radiation Protection Standards	WAC 246-221		Establishes standards for protection against radiation hazards.		
Radiation dose to individuals in restricted areas	WAC 246-221-010	A	Specifies dose limits to individuals in restricted areas for hands and wrists, ankles and feet of 18.75 rem/quarter and for skin of 7.5 rem/quarter.		All

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table C-3 Potential Chemical-Specific TBC

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected
Safe Drinking Water Act	42 U.S.C. 300f et seq.			
National Primary Drinking Water Regulations	40 CFR 141	Proposed maximum contaminant level goals (MCLGs) (Federal Register, July 18, 1991) are: Contaminant — MCLG Radium-226 — zero Radium-228 — zero Uranium — zero Gross alpha emitters — zero Beta and photon emitters — zero	Federal MCLGs are ARAR under MTCA when they are more stringent than other state standards.	All
National Primary Drinking Water Regulations; Radionuclides - Proposed Rules	FR Vol. 56, No. 138, July 18, 1991	Provides numerical standards for radionuclides corresponding to 4 mrem/yr dose through drinking water as follows (pCi/L): Tritium — 69,040 Carbon-14 — 3,200 Strontium-90 — 42 Technitium-99 — 3,790 Uranium-235 — 14.5	When promulgated, these proposed rules will replace sections in 40 CFR 141 and 142	All
Solid Waste Disposal Act, as amended by RCRA	42 U.S.C. 6901 et seq.			
Corrective Action for Solid Waste Management Units	40 CFR 264 Subpart S, proposed	Estabilishes requirements for investigation and corrective action for releases of hazardous waste from solid waste management units.		GW-4, GW-5, GW-6
U.S. Department of Energy Orders				
Radiation Protection of the Public and the Environment	DOE 5400.5	Establishes radiation protection standards for the public and environment.		
Radiation Dose Limit (All Pathways)	DOE 5400.5, Chapter II, Section 1a	The exposure of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem from all exposure pathways, except under specified circumstances.	Pertinent if remedial activities are "routine DOE activities."	All

Table C-3 Potential Chemical-Specific TBC
(Page 2 of 2)

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected
Radiation Dose Limit (Drinking Water Pathway)	DOE 5400.5, Chapter II, Section 1d	Provides a level of protection for persons consuming water from a public drinking water supply operated by DOE so that persons consuming water from the supply shall not receive an effective dose equivalent greater than 4 mrem per year. Combined radium-226 and radium-228 shall not exceed 5×10^{-9} μCi/mL and gross alpha activity (including radium-226 but excluding radon and uranium) shall not exceed 1.5×10^{-8} μCi/mL.	Pertinent if radionuclides may be released during remediation.	All

Table C-4 Potential Federal Action-Specific ARAR
(Page 1 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Federal Water Pollution Control Act (FWPCA), as amended by the Clean Water Act of 1977 (CWA)	33 U.S.C. 1251 et seq.		Creates the basic national framework for water pollution control and water quality management in the United States.	Applicable to discharges of pollutants to navigable waters.	
The National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	A	Part 122 covers establishing technology-based limitations and standards, control of toxic pollutants, and monitoring of effluent to assure limits are not exceeded.	Applicable if remediation includes wastewater discharge; also applies to storm water runoff associated with industrial activities. Effluent limitations established by EPA and included in NPDES permit.	GW-5, GW-6
NPDES Criteria and Standards	40 CFR §125.104		Best management practices program shall be developed in accordance with good engineering practice.		
Discharge of Oil	40 CFR Part 110	A	Prohibits discharge of oil that violates applicable water quality standards or causes a sheen of oil on water surface.	Runoff from site will need control for oily waste discharge to waters of the United States.	All
Safe Drinking Water Act (SDWA), as amended	42 U.S.C. 300f et seq.		Creates a comprehensive national framework designed to ensure the quality and safety of drinking water supplies.	Applicable to public water systems.	
Underground Injection Control (UIC) Program	40 CFR Part 144	A	Identifies the minimum requirements for UIC programs. Requires all UI wells to be permitted and describes permitting procedures.	Applicable for remedial action involving reinjection of groundwater.	GW-5
Criteria and Standards for the Underground Injection Control (UIC) Program	40 CFR Part 146	A	Establishes siting, construction, operating, monitoring, and closure requirements for all classes of injection wells. (Criteria and standards for class IV wells are reserved at this time.)	Applicable for remedial action involving reinjection of groundwater.	GW-5
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act (RCRA)	42 U.S.C.6901 et seq.		Establishes the basic framework for federal regulation of solid waste. Subpart C of RCRA controls the generation, transportation, treatment, storage, and disposal of hazardous waste through a comprehensive "cradle to grave" system of hazardous waste management techniques and requirements.	Hazardous waste generated by site remediation activities must meet RCRA generator and treatment, storage, or disposal (TSD) requirements.	

Table C-4 Potential Federal Action-Specific ARAR
(Page 2 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Identification and Listing of Hazardous Waste	40 CFR Part 261 [WAC 173-303-016]	A	Identifies by both listing and characterization, those solid wastes subject to regulation as hazardous wastes under Parts 261-265, 268, and 270.	Applicable if remediation techniques result in generation of hazardous wastes.	GW-5, GW-6
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262 [WAC 173-303]		Describes regulatory requirements imposed on generators of hazardous wastes who treat, store, or dispose of the waste on-site.	Applicable if remediation techniques result in generation of hazardous waste.	
Accumulation Time	40 CFR §262.34 [WAC 173-303-200]	A	Allows a generator to accumulate hazardous waste on-site for 90 days or less without a permit, provided that all waste is containerized and labeled.	Hazardous waste removed from the 100-Area operable units, and waste treatment residues, are subject to the 90-day generator accumulation requirements if the waste is stored on site for 90 days or less. If hazardous waste is stored for more than 90 days, the full permitting standards for TSD facilities must be met.	GW-5, GW-6
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264 [WAC 173-303]		Establishes requirements for operating hazardous waste treatment, storage, and disposal facilities.	Applies to facilities put in operation since November 19, 1980. Facilities in operation before that date and existing facilities handling newly regulated wastes must meet similar requirements in 40 CFR Part 265. Applies if remediation technique results in on-site treatment, storage, or disposal of hazardous waste.	
Land Disposal Restrictions (LDR)	40 CFR Part 268 [WAC 173-303-140- WAC 173-303-141]	A	Generally prohibits placement of restricted RCRA hazardous wastes in land-based units such as landfills, surface impoundments, and waste piles. Prohibits storage of restricted waste for longer than one year unless the owner/operator can prove storage is necessary to facilitate proper recovery, treatment, or disposal.	Applicable unless wastes have been treated, treatment has been waived, a treatment variance has been set for the waste, an equivalent treatment method petition has been approved, a no-migration petition has been approved, or the waste has been delisted.	GW-5, GW-6
Treatment Standards	40 CFR §§268.40- 268.44 [WAC 173-303-140]	A	Establishes treatment standards that must be met prior to land disposal.	Applicable if wastes contain RCRA hazardous constituents.	GW-5, GW-6

Table C-4 Potential Federal Action-Specific ARAR
(Page 3 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Clean Air Act, as amended	42 U.S.C. 7401 et seq.		A comprehensive environmental law designed to regulate any activities that affect air quality, providing the national framework for controlling air pollution.		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50		Sets National Ambient Air Quality Standards for ambient pollutants which are regulated within a region.		
Air Standards for Particulates	40 CFR §50.6	A	Prohibits average concentrations of particulate emissions in excess of 50 micrograms/m^3 annually or 150 micrograms/m^3 per 24-hour period.	A potential for particulate emissions exists during material handling or treatment, including incineration.	GW-5, GW-6
Air Standards for Lead	40 CFR §50.12	A	The national primary and secondary ambient air quality standard for lead and its compounds measured as elemental lead are 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter.	Applicable if particulates suspended during remedial activities are contaminated with lead, or if remediation includes incineration.	GW-5, GW-6
National Emissions Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61		Establishes numerical standards for hazardous air pollutants.		
Radionuclide Emissions from DOE Facilities (except Airborne Radon-222)	40 CFR §61.92	A	Prohibits emissions of radionuclides to the ambient air exceeding an effective dose equivalent of 10 mrem per year.	Applicable to incinerators and other remedial technologies where air emission may occur.	GW-5, GW-6

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table C-5 Potential State Action-Specific ARAR
(Page 1 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Department of Ecology	43.21A RCW		Vests the Washington Department of Ecology with the authority to undertake the state air regulation and management program.		
Air Pollution Regulations	WAC 173-400		Establishes requirements for the control and/or prevention of the emission of air contaminants.	Applicable if emission sources are created during remedial action.	
Standards for Maximum Emissions	WAC 173-400-040	A	Requires best available control technology be used to control fugitive emissions of dust from materials handling, construction, demolition, or any other activities that are sources of fugitive emissions. Restricts emitted particulates from being deposited beyond Hanford. Requires control of odors emitted from the source. Prohibits masking or concealing prohibited emissions. Requires measures to prevent fugitive dust from becoming airborne.	Applicable to dust emissions from cutting of concrete and metal and vehicular traffic during remediation.	GW-2, GW-3, GW-4, GW-5, GW-6
Emission Limits for Radionuclides	WAC 173-480		Controls air emissions of radionuclides from specific sources.	Applicable to remedial activities that result in air emissions.	
New and Modified Emission Units	WAC 173-480-060	A	Requires the best available radionuclide control technology be utilized in planning constructing, installating, or establishing a new emission unit.	Applicable to remedial actions that result in air emissions.	GW-3, GW-4, GW-5, GW-6
Washington Clean Air Act	RCW 70.94				
Controls for New Sources of Toxic Air Pollutants	WAC 173-460		Establishes systematic control of new sources emitting toxic air pollutants.		
Demonstrating Ambient Impact Compliance	WAC 173-460-080	A	Requires the owner or operator of a new source to complete an acceptable source impact level analysis using dispersion modeling to estimate maximum incremental ambient impact of each Class A or B toxic air pollutant. Establishes numerical limits for small quantity emission rates.	Applicable to remedial alternative with the potential to release toxic air pollutants.	GW-3, GW-4, GW-5, GW-6

Table C-5 Potential State Action-Specific ARAR
(Page 2 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Hazardous Waste Management Act of 1976 as amended in 1980 and 1983[1]	70.105 RCW		Establishes a statewide framework for the planning, regulation, control, and management of hazardous waste.		
Dangerous Waste Regulations	WAC 173-303		Establishes the design, operation, and monitoring requirements for management of hazardous waste.	Includes requirements for generators of dangerous waste. Dangerous waste includes the full universe of wastes regulated by WAC 173-303 including extremely hazardous waste.	
Model Toxics Control Act	70.105D RCW		Authorizes the state to investigate releases of hazardous substances, conduct remedial actions, carry out state programs authorized by federal cleanup laws, and take other actions.		
Hazardous Waste Cleanup Regulations	WAC 173-340		Addresses releases of hazardous substances caused by past activities, and potential and ongoing releases from current activities.	Applicable to facilities where hazardous substances have been released, or there is a threatened release that may pose a threat to human health or the environment.	
Selection of Cleanup Actions	WAC 173-340-360	R&A	Establishes cleanup requirements to include in cleanup plans. Identifies technologies to be considered for remediation of hazardous substances.		All
Cleanup Actions	WAC 173-340-400	R&A	Ensures that the cleanup action is designed, constructed, and operated in accordance with the cleanup plan and other specified requirements.		All
Institutional Controls	WAC 173-340-440	R&A	Requires physical measures such as fences and signs to limit interference with cleanup, and legal and administrative mechanisms to enforce them.		GW-2, GW-3, GW-4, GW-5, GW-6
Regulation of Public Groundwater	90.44 RCW	R&A	Sets requirements for withdrawal and management of state groundwater.	Applicable if remediation includes groundwater withdrawal.	GW-3, GW-5, GW-6

[1]The Hazardous Waste Management Act and regulations pursuant to the Act provide the statutory and regulatory basis for state authorization to implement RCRA. State of Washington regulations that are equivalent to RCRA regulations are cited in brackets in the federal ARARs. The WAC 173-303 regulations cited in this section are those judged to be more stringent than RCRA regulations.

Table C-5 Potential State Action-Specific ARAR
(Page 3 of 3)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Solid Waste Management Act	70.95 RCW		Establishes a statewide program for solid waste handling, recovery, and/or recycling.	Applicable if management of solid waste occurs during remediation. Solid waste controlled by this Act includes garbage, industrial waste, construction waste, ashes, and swill.	
Minimum Functional Standards for Solid Waste Handling	WAC 173-304		Establishes requirements to be met statewide for the handling of all solid waste.		
On-site Containerized Storage, Collection, and Transportation Standards	WAC 173-304-200	R&A	Sets requirements for containers and vehicles to be used on site; requires monthly inspections and retention of inspection records for at least two years.		All
Water Pollution Control Act	90.48 RCW		Prohibits discharge of polluting matter in waters.		
State Waste Discharge Permit Program	WAC 173-216		Implements a state permit program, applicable to the discharge of waste materials from industrial, commercial, and municipal operations into the ground and surface waters of the state. Excludes discharges under NPDES and underground injection control programs.		
Permit Terms and Conditions	WAC 173-216-110	R&A	Requires the use of all known, available, and reasonable methods of prevention, control, and treatment.		GW-5, GW-6
Water Well Construction Act	18.104 RCW				
Standards for Construction and Maintenance of Wells	WAC 173-160	A	Establishes minimum standards for design, construction, capping, and sealing of all wells; sets additional requirements including disinfection of equipment, abandonment of wells, and quality of drilling water.	Applicable if water supply wells, monitoring wells, or other wells are utilized during remediation.	GW-2, GW-3, GW-4, GW-5, GW-6

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table C-6 Potential Action-Specific TBC

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected
U.S. Department of Energy Orders				
Radiation Protection of the Public and the Environment	DOE 5400.5	Establishes standards and requirements for operations of DOE and DOE contractors respecting protection of the public and the environment against undue risk of radiation.		All

Table C-7 Potential Federal Location-Specific ARAR (Page 1 of 2)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Archaeological and Historical Preservation Act of 1974	16 U.S.C. 469	A	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	Applicable when remedial action threatens significant scientific, prehistorical, historical, or archeological data.	GW-2, GW-3, GW-4, GW-5, GW-6
Endangered Species Act of 1973	16 U.S.C. 1531 et seq.		Prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival.		
Fish and Wildlife Services List of Endangered and Threatened Wildlife and Plants	50 CFR Parts 17, 222, 225, 226, 227, 402, 424	A	Requires identification of activities that may affect listed species. Actions must not threaten the continued existence of a listed species or destroy critical habitat.	Requires consultation with the Fish and Wildlife Service to determine if threatened or endangered species could be impacted by activity.	All
Historic Sites, Buildings, and Antiquities Act	16 U.S.C. 461	A	Establishes requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts to such resources must be mitigated.		GW-2, GW-3, GW-4, GW-5, GW-6
National Historic Preservation Act of 1966, as amended.	16 U.S.C. 470 et seq.	A	Prohibits impacts on cultural resources. Where impacts are unavoidable, requires impact mitigation through design and data recovery.	Applicable to properties listed in the National Register of Historic Places, or eligible for such listing.	GW-2, GW-3, GW-4, GW-5, GW-6
Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (RCRA)	42 U.S.C. 6901 et seq.		Establishes the basic framework for federal regulation of solid and hazardous waste.		
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257		Sets criteria for determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment.		
Floodplains	40 CFR §257.3-1	A	Prohibits facilities or practices in floodplains from restricting the flow of the base flood, reducing the temporary water storage capacity of the floodplain, or causing washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources.		GW-5, GW-6,

Table C-7 Potential Federal Location-Specific ARAR
(Page 2 of 2)

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Endangered Species	40 CFR §257.3-2	A	Prohibits facilities or practices from causing or contributing to the taking of any endangered or threatened species of plants, fish, or wildlife. Prohibits destruction or adverse modification of habitat of endangered or threatened species.		All
Wild and Scenic Rivers Act	16 U.S.C 1271	R&A	Prohibits federal agencies from recommending authorization of any water resource project that would have a direct and adverse effect on the values for which a river was designated as a wild and scenic river or included as a study area.	The Hanford Reach of the Columbia River is under study for inclusion as a wild and scenic river.	GW-3, GW-4, GW-5, GW-6

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table C-8 Potential State Location-Specific ARAR

Description	Citation	A/ R&A*	Requirements	Remarks	Alternatives Potentially Affected
Habitat Buffer Zone for Bald Eagle Rules	RCW 77.12.655				
Bald Eagle Protection Rules	WAC 232-12-292	A	Prescribes action to protect bald eagle habitat, such as nesting or roost sites, through the development of a site management plan.	Applicable if the areas of remedial activities includes bald eagle habitat.	All
Regulating the Taking or Possessing of Game	RCW 77.12.040				
Endangered, Threatened, or Sensitive Wildlife Species Classification	WAC 232-12-297	A	Prescribes action to protect wildlife classified as endangered, threatened, or sensitive, through development of a site management plan.	Applicable if wildlife classified as endangered, threatened, or sensitive are present in areas impacted by remedial activities.	All

*NOTE: A = Applicable, R&A = Relevant and Appropriate

Table C-9 Potential Location-Specific TBC

Description	Citation	Requirements	Remarks	Alternatives Potentially Affected
Floodplains/Wetlands Environmental Review	10 CFR Part 1022	Requires federal agencies to avoid, to the extent possible, adverse effects associated with the development of a floodplain or the destruction or loss of wetlands.	Pertinent if remedial activities take place in a floodplain or wetlands.	All
Protection and Enhancement of the Cultural Environment	Executive Order 11593	Provides direction to federal agencies to preserve, restore, and maintain cultural resources.	Pertains to sites, structures, and objects of historical, archeological, or architectural significance.	All
Hanford Reach Study Act	P.L. 100-605	Provides for a comprehensive river conservation study. Prohibits the construction of any dam, channel, or navigation project by a federal agency for 8 years after enactment. New federal and non-federal projects and activities are required, to the extent practicable, to minimize direct and adverse effects on the values for which the river is under study and to utilize existing structures.	This law was enacted November 4, 1988.	GW-3, GW-4, GW-5, GW-6

APPENDIX D

DETAILED DESCRIPTIONS OF REMEDIAL ALTERNATIVES FROM THE 100 AREA FEASIBILITY STUDY PHASES 1 AND 2

1.0 GROUNDWATER REMEDIAL ALTERNATIVE DESCRIPTIONS

The alternatives considered for treatment of the 100 Area groundwater operable unit were developed and screened in the *100 Area Feasibility Study Phases 1 and 2* (DOE-RL 1994a). This section of the FFS presents detailed descriptions of each groundwater alternative retained from the 100 Area FS for more detailed analysis. The descriptions for these alternatives (referred to as the general alternatives) are expanded from the information presented in the 100 Area FS and are modified as needed to reflect new information gathered since preparation of the FS. These alternative descriptions will be modified (as needed) to reflect site-specifics in the individual operable unit FFS.

1.1 ALTERNATIVE GW-1

1.1.1 Description

Alternative GW-1, the no action alternative, is required by the NCP to serve as a baseline for evaluation of other alternatives. The no action alternative may be selected for sites where contamination does not exceed the level of unacceptable risk, where site contamination is in compliance with ARAR, where short-term risks associated with the remedial action exceed the risk of no action, or where the cost of remediation is excessive compared to the benefit gained in risk reduction. The no action alternative assumes no further action at a site. For example, no action for the groundwater operable unit consists of continued existing groundwater monitoring events. The contamination is allowed to dissipate through natural attenuation processes. For radionuclides this is mainly natural radioactive decay. The effectiveness of the natural attenuation process is related to the half-life of the radionuclide and the affinity of the radionuclide to sorb to the Hanford soils. For other contaminants, such as chromium, the major attenuation factor is advection/dispersion which depends on natural groundwater flow and the river flushing action to reduce concentrations.

1.2 ALTERNATIVE GW-2

A single alternative has been developed for the GRA of institutional controls (designated Alternative GW-2). The remedial technologies and associated process options specified for this alternative in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a) have been modified. Based on the requirement to consider only the recreational use scenario, identification of an alternate water supply for residential, industrial, or agricultural use is no longer necessary. Therefore, the institutional controls proposed to prevent access to contaminated groundwater plumes beneath the 100 Area are:

- access restrictions:
  - deed restrictions
  - water rights restrictions

- monitoring:
    - groundwater monitoring.

1.2.1 Description

The institutional controls alternative for groundwater involves restricting access to contaminated sites within the 100 Area. The restrictions included in this alternative are unique to groundwater media. Types of restrictions are defined as follows:

- Deed restrictions may be established to place limitations on groundwater use. These limitations could specify restrictions on acceptable groundwater uses and may take the form of covenants that limit activities resulting in human contact. Deed restrictions may include a prohibition on groundwater use or less stringent limitations on use for off-site farming and industrial activities.

- Water-rights restrictions limit access to contaminated groundwater. The water-rights restrictions could be imposed by deed restrictions, as discussed above, or by designated use, should the title to the 100 Area remain with the federal government. Water-rights restrictions merely designate the acceptable use of 100 Area groundwater (if at all) for recreational use, such as temporary drinking water. This action may require an additional change in water-rights administration to be effective. At this time, no state water-rights restrictions are necessary if consumptive use is <5,000 gal/day (WAC 173-160-040).

In addition to restricting groundwater use and access to groundwater, the institutional action alternative also includes groundwater and environmental monitoring. Monitoring will be required to determine if and when institutional controls to restrict access to groundwater are no longer necessary.

Institutional controls are assumed to be in place during the period of DOE control. After DOE release of the site, deed and water rights restrictions can be implemented to prevent access.

1.3 ALTERNATIVE GW-3

Alternative GW-3 has been developed as a containment GRA. The objective of Alternative GW-3 is to eliminate source to receptor pathways by preventing migration of contaminated groundwater to environmental resources, such as the Columbia River, and preventing further migration of contaminated groundwater outside the operable unit. In order to achieve this objective, Alternative GW-3 is designed to isolate and contain existing contaminant plumes. Through the use of cutoff walls and extraction/injection wells, contaminant plumes would be contained to prevent migration and isolated to prevent further contamination of the unconfined aquifer. In addition to containment and isolation of contaminant plumes, this remedial action would be implemented to minimize overall effects on the general hydrologic conditions of the unconfined aquifer. The containment alternative objectives must be maintained until natural attenuation reduces concentrations to acceptable levels or until alternate cleanup standards can be negotiated and agreed upon by the parties to the Tri-Party Agreement. Contaminants that are persistent in the environment especially may require additional remedial action or determination of alternate cleanup levels.

1.3.1 Description

Alternative GW-3 was initially developed in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a). The alternative initially developed forms the baseline from which modifications are made for application to the 100-HR-3 Operable Unit. The general description of this alternative is based on the remedial technologies and associated process options specified in the 100 Area FS for containment of contaminated groundwater plumes beneath the 100 Area:

- vertical barriers:
  - cutoff walls

- hydraulic control:
  - extraction wells
  - injection wells (as necessary)

- monitoring:
  - groundwater monitoring.

1.3.1.1 Cutoff Wall Options. The general description of this alternative includes several subsurface barrier (cutoff wall) technologies that are potentially applicable in the 100 Area. A cutoff wall is a subsurface barrier designed to prevent the flow of contaminated groundwater. Several cutoff wall technologies are available that may be applicable in the 100 Area depending on site-specific conditions and requirements. Each technology has advantages and disadvantages based on the specific applications. Therefore, no one specific cutoff wall technology will be universally applicable in the 100 Area. The cutoff wall technologies considered potentially applicable in the 100 Area are:

- slurry wall
- deep soil mixing
- sheet piling
- injection grouting.

The specific cutoff wall technology selected to represent the containment alternative will be determined on an operable unit-specific basis. In this manner, the cutoff wall technology most applicable to operable unit site-specific conditions and requirements can be specified.

In situations where subsurface barriers may not be applicable due to technical limitations such as wall depth requirements, hydraulic control measures may be specified as the method of contaminant plume containment. Hydraulic control provides containment by extraction of contaminated groundwater from the downgradient front of the plume followed by reinjection in the upgradient portion of the plume. Continuous extraction and injection can effectively isolate contaminant plumes, but are considered operating and maintenance intensive compared to vertical barriers. This method of containment would only be used in situations where the use of a subsurface barrier is not applicable. This alternative does not represent a complete solution for persistent contaminants but is consistent with the IRM approach and with the final remedy.

1.3.1.1.1 Slurry Walls. Typical slurry wall construction involves trench excavation under a slurry. The slurry provides hydraulic shoring to maintain the integrity of the trench while at the same time forming a low permeability filter cake on the trench walls that prevents fluid loss into the surrounding soil. Once a portion of the trench has been excavated to depth, a backfill material is added. In this manner, excavation and backfilling occur simultaneously until the wall is complete. The completed wall is designed to be less permeable than the surrounding native soil and thereby forms a barrier to groundwater flow.

Backfill materials commonly used in slurry wall construction include mixtures of bentonite slurry and soil, or mixtures of cement, bentonite, and water. Slurry walls constructed of soil/bentonite are generally the least permeable, least susceptible to contaminant degradation, and least expensive (Spooner et al. 1985). Slurry walls constructed of cement/bentonite are generally easier to install, provide more strength, and can be installed to greater depths (Spooner et al. 1985).

The depth of a slurry wall is dependent on the depth of the aquitard beneath the contaminant plume. To ensure effective containment of contaminant plumes, slurry walls must be keyed-in to a low permeability or aquitard zone beneath the aquifer. In the case of the 100 Area, this aquitard may be a silty sand zone that separates the coarse sand and gravel zones in the unconfined aquifer or a paleosol/overbank deposit at the base of the unconfined aquifer. However, if contaminant plumes extend throughout the Ringold aquifers, the clay, silt, and fine sand of the Ringold lower mud unit ("Blue Clay") may be the nearest aquitard. In any case, the required depth of the slurry wall will depend on the nearest aquitard.

Filter cake formation regulates the amount of slurry lost to the surrounding soils. Formation of the filter cake depends on the permeability of the soil, pore size, type of slurry, and any additives used. In gravel beds, which allow groundwater velocities of 1 to 10 cm/sec, the pores are too large to be easily closed. Fines, such as sand, are used in these cases to assist pore space blockage. Slurries are typically mixed with up to 10% fines to assist formation of the filter cake. The Hanford formation is classified as a sandy gravelly unit with a water movement rate of about 0.1 cm/sec (DOE-RL 1993b). Generally, a bentonite/soil slurry would be chosen because of its low permeability; however, sand or other fines may be added to the slurry to increase filter cake formation. Testing must be done on the specific soil conditions to determine the need to add fines.

The equipment used for excavating slurry wall trenches is also dependent on the required wall depth and the former is limited by the maximum digging depth capabilities of the machinery. In general, long-reach type backhoe equipment can provide excavation depth up to approximately 24 m (80 ft) (Spooner et al. 1985). Draglines or clamshell excavation equipment is typically required for depths >24 m (>80 ft) (Spooner et al. 1985). The presence of large rock or boulders can present problems during the implementation phase. Most of the large boulders are associated with the Hanford formation; the Ringold Formation generally does not contain these boulders. The potential for large boulders is reduced by placing the wall as close to the river as possible because the Hanford formation has often been eroded in this area. By placing the barrier close to the river, the effectiveness is increased and the need to excavate through the Hanford formation is minimized.

Slurry preparation and placement generally requires raw material areas, mixing equipment, transport equipment, storage ponds, and cleaning equipment. Raw materials required for a slurry mixture include water, bentonite, cement (if specified), and soil (engineered if necessary). Formation of the slurries can be accomplished with venturi (flash) mixers or paddle (vortex) mixers (Spooner et al. 1985). Storage ponds provide surge capacity for continuous application of slurry into excavation trenches. Pumps, pipes, valves, hoses, and other associated fitting and tools are required to move the slurry from mixing area to the storage pond or from storage pond to the excavation.

Backfill preparation and placement also requires raw materials storage, mixing, transport, and placement equipment. Backfilling is generally less complicated than slurry preparation and placement. Raw materials include bentonite, soil, and cement (if necessary). Mixing is generally carried out with bucket loaders or bulldozers, but can also be accomplished mechanically with a pugmill. Initial placement of backfill in the trench requires a clamshell to lower the material to the bottom. This prevents segregation of backfill particles and entrapment of slurry pockets with the backfill (Spooner et al. 1985). Thereafter, a bulldozer or bucket loader can simply push backfill into the trench.

Should future removal of the slurry wall be required, the wall can be excavated, drilled and perforated, or broken by blasting in order to allow groundwater movement through the barrier similar to initial conditions (prior to remedial action).

1.3.1.1.2 Deep Soil Mixing. Deep soil mixing is a commercially available technology for construction of vertical barriers with properties similar to slurry walls. The deep soil mixing technique uses a crane-mounted boring/mixing tool containing injection nozzles. The tool is initially driven into the soil formation to the required cutoff wall depth. The tool is then partially withdrawn (approximately half the cutoff wall depth) to begin injection of slurry material. As injection continues the tool is driven back down to the required cutoff wall depth. Injection is continued until the tool is completely withdrawn. The tool mixes the slurry and soil throughout the injection process. The slurry materials selected for injection are typically cement, bentonite, or cement-bentonite mixtures, depending on the required permeability. The cutoff wall is formed by installation of a continuous series of overlapping columns.

The primary advantage of deep soil mixing is that the technique does not require removal of contaminated soil. Mixing occurs in the subsurface without exposing workers and the environment to contaminated soil and groundwater. The technique essentially eliminates disposal requirements, handling contaminated materials, as well as worker and environmental exposures.

The operational depth of deep soil mixing is dependent on the equipment specifications and the geologic formation in which the cutoff wall is to be installed. The deep soil mixing method performs poorly in formations with boulders. The presence of large rock or boulders (>18") in the Hanford formation can present problems during implementation. Large boulders can be removed by pre-excavation or worked around by offsetting the columns. A typical deep soil mixing system requires and area of 130' x 50' to accommodate set up and tear down the crane. Operation of the system also requires an onsite support area and an adjacent equipment decontamination pad. The soil formation must be able to support the system (crane and mixing tool), approximately 15 pounds per square foot.

Removal of the deep soil mixed barrier would be accomplished in the same manner as the slurry wall.

1.3.1.1.3 Sheet Pile. Sheet piling is a commercially available technology that has been widely used for earth retaining structures such as dock walls bulkheads, river walls piers and dry dock walls. The technology has more recently become used for contaminated groundwater control as seepage cutoff walls. Sheet steel piling consists of hot-rolled steel sections provided with clutches or interlocks for connecting successive piles to one another such that a continuous wall can be formed. The sheet piles are usually driven in pairs using hammers of the double acting type or diesel hammers. The driving of each new sheet is started once the neighbor sheet has been about one-third driven. Since the sheet pile is assumed not to undergo bending moments, the anticipated soil resistance to be overcome during driving will determine the thickness of steel required in the cross section, as well as the quality of steel from which the piles should be manufactured. The interlock (or annulus) between sheet piles is completely soil tight and can be injected with a sealant (such as grout) to ensure an appropriate impermeability.

Characteristics of the geologic formation can impose some limitations in the applicability of the sheet pile technique. Splitting the web during driving is not uncommon, particularly when obstructions or dense granular soils are being penetrated. Driving sheet piles becomes difficult and often times impracticable in formations which contain large boulders. Corrosion is another factor to be taken into consideration when evaluating the use of sheet pile cutoff walls. Groundwater chemistry will have the most significant impact on corrosion of a sheet pile wall, however, a protective coating can be applied if necessary. Depth limitations exist for the sheet pile technology with walls currently extending <30 m (100 ft) in depth.

The sheet pile wall can be removed by pulling the sheets out under vibration. This process is more difficult when the joints are grouted. A sheet pile wall is being designed for N Springs. Information from this application should be useful for the other 100 Area groundwater operable units. If this information is not available in time to meet the schedules for groundwater IRM, then additional testing of the implementability of the sheet pile wall may be necessary in conjunction with a geotechnical investigation.

1.3.1.1.4 Jet Grouting. Grouting technology has wide applications in engineering practice. Grout curtains are typically used as containment barriers to control seepage through dam foundations, protect excavations conducted under groundwater level, and prevent contaminant migration. Injection grouting has also been used for other engineering applications such as soil improvement, pre-stressing of rock and lifting and leveling of structures. Grout injection is a technique used to force grout into voids and fissures of a soil formation to obtain a desired property, such as reduced permeability.

Jet grouting typically involves drilling boreholes into a formation and then injecting grout under pressure until the voids around the injected section are filled to satisfy a specified design condition. The properties of the grout vary with the application, and often times a combination of different grouts are selected based on the specific characteristics of the site. Grouting consists of the following sequence of operations (Nonveiller 1989):

- drilling injection boreholes in a predetermined arrangement and depth
- preparation, proportioning, weighing and mixing of the selected grout suspension
- injecting the prepared suspension into the designated section of the borehole such that soil voids are filled.

The spacing of the injection holes is based on the results obtained from test grouting plots injected at the site. Rotary or percussion rotary drilling rigs are used for drilling the injection holes. Rotary percussion drill rigs can be used for depths up to 180 m with drilling speeds of 20 m/h (65 ft/h) (Nonveiller 1989). Rotary percussion is considered the most suitable drilling method in Hanford formation due to the potential for subsurface boulders.

The appropriate grouting compound for a specific project is dependent upon the characteristics and properties of the geologic formation in which the cutoff wall is to be installed. Thick cement, clay and bentonite suspensions are typically recommended for the grouting compounds used for uniform medium sand and gravel (Nonveiller 1989). Other suspensions such as clay cement, bentonite gel and clay gel are used in similar applications. Treatability studies would be required to determine the optimum grouting compound for use in the geologic formation of the 100 Area.

The efficiency of injection grouting depends on the maximum pressure at which a grouted section of a borehole will become saturated. Low saturation pressures will permeate only a small volume of the soil whereas high pressures will cause hydrofracturing. The injection pressure must always be higher than the overburden stress at the level of injection. Formulae to calculate injection pressures are provided in literature (Nonveiller 1989).

In granular soils, the discharge of grouting decreases as the injection process takes place (at constant injection pressure). This decrease in permeability is a function of three parameters: the grain size of solids elements of the grout, the percentage of dry materials, and the state of flocculation (Winterkorn and Fang 1975). Laboratory experiments have demonstrated that slightly loaded grouts would more easily penetrate a soil than a highly loaded grout. Therefore, engineering practice shows that the cement quantity should be minimized to obtain the desired resistance into the soil. Stability of the grout can be ensured by low percentages of ultracolloidal clay (i.e., bentonite). Typical cement-bentonite grouts used to form low permeability soils will contain approximately 170 kg (374 lb) of dry materials for 1 m^3 (35 ft^3) grout.

The state of flocculation is also a parameter of concern. A stable suspension penetrates the soil more easily when it contains few grains or when the diameters of the grains is small. This means that slightly loaded grouts without any cement (i.e., clay and bentonite grout) are used for impermeability requirements. Clay or bentonite should be dispersed in the grout as elementary grains and not in flocculated form.

The total grout volume necessary is based on the void volume of the soil. However, the radius of grout flow is typically irregular and usually involves significant losses of grout into unintended areas of the formation. Permeable formations, such as Hanford formation, can result in large losses of grout if the grouting selection has not been carefully planned.

The depth limitation of injection grouting is that of the drilling and pressure unit devices. Depths of up to 200 m (656 ft) have been reported in literature (Nonveiller 1989).

The grout wall is likely the hardest to remove; the method of removal would be the same as the slurry wall and deep soil mixed barrier.

1.3.1.2 Containment System Configuration. The containment response action can be implemented in a number of different ways. The optimum number and location of cutoff walls and extraction/injection wells required to contain contaminant plumes in the 100 Area will be determined by hydrologic modeling. Cutoff walls can be constructed to completely surround contaminant plumes; to divert uncontaminated groundwater around contaminant plumes; or to prevent migration of contaminant plumes. Extraction wells can be operated to produce an artificial gradient that stagnates movement of contaminant plumes, to intercept uncontaminated groundwater before contacting contaminant plumes, or to intercept contaminated groundwater movement around the barrier. In general, the combination of cutoff walls and extraction/injection wells will be located such that contaminated groundwater plumes are isolated and contained.

It is assumed for purposes of this feasibility study that the containment alternative is implemented as follows: cutoff walls would be built to prevent migration of contaminant plumes; groundwater extraction wells, if necessary, would be placed to intercept contaminated groundwater at the ends of the wall; and injection wells would be placed to minimize the effects on the overall hydrologic conditions of the unconfined aquifer, if necessary. The general concept of Alternative GW-3 is presented graphically in Figure D-1.

All the barrier options are assumed to have expected useful lives much greater than the IRM period.

1.3.1.3 Disposal Distances and Location. Wastes requiring disposal may result from drilling activities and/or construction of the cutoff walls. Slurry wall construction would result in generation of more significant quantities of waste than the other cutoff wall technologies. During slurry wall construction, the addition of slurry agents results in a net excess of soil. Approximately 33% of the total excavated volume for a soil-bentonite wall and up to 60% for a soil-bentonite-cement wall would require disposal (Spooner et al. 1985). To minimize the volume of contaminated soil produced, materials could be segregated so that the uncontaminated vadose zone soil would make up most of the excess soil.

Radiologically and/or chemically contaminated soils will be transported by truck or rail to the ERDF, W-025, or another site for disposal. It is anticipated that all wastes will meet ERDF waste acceptance criteria only preliminary guidelines for waste acceptance criteria have been identified in the ERDF conceptual design report.

Liquid waste disposal is not applicable to Alternative GW-3. Although hydraulic control (extraction) wells may be used to remove groundwater to stop contaminant migration around the ends of the wall, this water would be reinjected into the aquifer in a recycle loop.

1.3.1.4 Monitoring. The containment-action alternative also includes groundwater and environmental monitoring. Monitoring will be required to evaluate the long-term effectiveness of slurry walls and provide information to base subsequent decisions regarding the continued need for containment actions.

1.4 ALTERNATIVE GW-4

A single alternative has been developed for the in situ treatment general response action (designated GW-4). The remedial technologies and associated process options selected in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a) for in situ groundwater treatment are:

- biological treatment:
  - biodenitrification (nitrates)
- physical treatment:
  - air sparging (this may be combined with soil vapor extraction (SVE) to eliminate venting organics to the atmosphere)
- monitoring:
  - groundwater monitoring.

1.4.1 Objective

The objective of Alternative GW-4 is to eliminate source to receptor pathways by in situ remediation of contaminated groundwater plumes. In order to achieve this objective, Alternative GW-4 is designed to eliminate nitrate and organic contaminated groundwater in situ. Biodenitrification and air sparging are the in situ treatment technologies specified to remove nitrate and volatile organic compound (VOC) contamination, respectively. Other in situ treatment technologies such as biodegradation may be required on a case-by-case basis to remove semi- or non-volatile organics that may also be present in contaminated groundwater plumes. It is noted here that the objective of this alternative will not be completely satisfied due to limitations in the current status of in situ remedial technologies. Currently there are no proven or innovative in situ treatment technologies capable of reducing or eliminating the health and environmental risks from metals and radionuclides.

1.4.2 System Configuration

Although nitrates are expected at each of the 100 Area groundwater operable unit, the location of organic contamination is not as well defined. The LFI for the groundwater operable unit describe the contamination present in 100 Area groundwater.

Air sparging and biodenitrification systems can be implemented in several different ways. Each system requires an injection well system to ensure treatment encompasses the entire plume. Extraction well systems are generally not necessary since treatment occurs below ground. However, extraction wells can be used to facilitate treatment or satisfy regulatory requirements. In situ air sparging systems can utilize extraction wells (i.e., soil vapor extraction) to prevent VOC from venting into the atmosphere (potential regulatory requirement) or to facilitate vertical migration of volatilized contaminants. In situ bioremediation systems utilize extraction wells to facilitate effective mixing of nutrients, microbes, and contaminants.

The size and configuration of Alternative GW-4 treatment systems will be determined by the extent of nitrate and organic contamination in 100 Area groundwater. Optimizing the number and location of treatment systems will be determined by hydrologic modeling. Optimizing operating parameters of the treatment systems will be determined by laboratory and pilot-scale testing as well as treatability studies.

1.4.3 Unit Operations

The concept of in situ treatment technologies specified for Alternative GW-4 are presented graphically in Figure D-2. Process operations, equipment requirements, and design considerations are described below.

1.4.3.1 In Situ Biodenitrification. Development and demonstration of in situ bioremediation of nitrates and carbon tetrachloride by indigenous microbes in Hanford groundwater is currently ongoing (Skeen et al. 1993). The process under development involves stimulating indigenous microorganisms to reduce nitrates to nitrogen gas during metabolization of organic carbon. To facilitate this process for remediation of 100 Area nitrate plumes, additions of nutrients (e.g. phosphorus) and a carbon source (acetate or methanol) may be required. The denitrification process is chemically represented according to the following simplified reaction:

$$NO_3^{-1} \xrightarrow{\textit{Bacterial Metabolic Process}} N_2\uparrow$$

The in situ biodenitrification process proposed involves a combination of extraction and injection wells. Placement of these wells is specified such that a closed pumping circuit is developed between extraction and injection wells. Well-to-well interaction is achieved by using one well for injection and nutrient addition and another well for extraction (Skeen et al. 1993). Extracted groundwater is transferred to a series of nutrient mixing tanks before injection back into the aquifer. The interaction between wells enhances flow and ensures proper mixing between wells (Skeen et al. 1993). Concentrations of additives required are based on pilot tests and continuous monitoring of extracted groundwater.

Equipment required for the in situ bioremediation scheme includes extraction wells, injections wells, nutrient feed tanks, mixing tanks, and associated pumps, piping, valves, monitoring and control systems. Due to the potential for leaks and spills in any hazardous liquid system, secondary containment measures may also be required in the event of an accident. Such measures could include double walled piping, berms around tanks, and overflow collection equipment.

The number and location of injection and extraction wells would be determined on the basis of hydrologic modeling. Design, installation, and operation requirements for the extraction and injection wells will be similar to standard production water wells. The primary design consideration for these wells is locating and sizing the screened area such that only that portion of the aquifer containing nitrate contamination is affected and the interaction between wells facilitates the closed pumping circuit concept described above.

Prior to injecting groundwater and additives back into the aquifer, mixing is required to ensure homogeneity. Nutrient mixing tanks utilizing mechanical agitation by a motor driven internal impeller are specified for this purpose. The specified mixing tanks operate on a continuous basis with the capability of maintaining a design residence time.

Nutrient feed can be made directly into the mixing tanks or the piping leading to the mixing tanks. Nutrient feed tanks are sized according to the required capacity of the system. A small capacity pump or gravity feed system will be required to inject nutrients at the specified location in the system.

1.4.3.2 Air Sparging. Air sparging is proposed for remediation of isolated plumes of VOC contamination in 100 Area groundwater. This remediation technology is similar to air stripping and involves injecting air into the soil or strata below contaminated groundwater plumes. Volatile organic compounds dissolved in groundwater and adsorbed onto soils are volatilized into the gas phase as air bubbles flow upward through the water column (Hazardous Waste Consultant 1993). A crude air stripping process is developed where the soil in the aquifer acts as tower packing that maximizes water surface area contact with air. Stripped contaminants are either drawn upward and collected with a vapor extraction system or, if permissible, allowed to naturally migrate to the surface and enter the atmosphere. An additional effect of injecting air into the aquifer is that natural aerobic biodegradation may be enhanced.

Air sparging is generally most effective in coarse-grained soils. Fine-grained soils tend to require greater air injection pressures that can result in lateral rather than vertical dispersion of air (Hazardous Waste Consultant 1993). Air movement in heterogeneous soils will follow the path of least resistance and can therefore short circuit the intended area of influence. The potential effects of short circuiting include missing target contamination due to vertical channeling and/or horizontal migration of contamination (Hazardous Waste Consultant 1993). High air pressures will likely be required for application in the 100 Area due to the heterogenous hydrostratigraphy of the unconfined aquifer.

An additional concern involves the heterogeneity of vadose zone soils which range in particle size from boulders to silt. The heterogeneity of vadose zone soils may prevent effective natural migration of stripped VOC to the surface for venting to the atmosphere. Potential for horizontal channelling may result in contaminant migration without venting to the atmosphere. To eliminate this potential, installation of a soil vapor extraction system is required with well screens located just above the saturated zone. The vapor extraction system will capture volatilized contaminants before lateral migration in the vadose zone can occur.

The number, location, and spacing of injection and extraction wells will be determined on the basis of modeling and pilot tests. Pilot tests are used to determine the radius of influence of injection and extraction wells within the subsurface of the area of contamination. In general, the radius of influence is larger in highly permeable soils and smaller in low permeability soils (Hazardous Waste Consultant 1993). To ensure effective contaminant removal, injection and extraction wells are spaced such that the radius of influence of each system is overlapping.

There are four types of well configurations used for in situ air sparging: spaced wells, nested wells, horizontal wells, and combined horizontal/vertical wells (Hazardous Waste Consultant 1993). The spaced well configuration is most common and involves the use of independent vertical wells to perform extraction and injection. The nested well configuration involves the use of a single vertical borehole to perform both injection and extraction. The horizontal well configuration utilizes horizontal drilling techniques or trenching to install injection and extraction wells. Combined horizontal/vertical wells uses a combination of both vertical and horizontal wells to perform injection and extraction. The configuration best suited for remediation of 100 Area sites must be determined on a case-by-case basis.

Equipment requirements for the proposed in situ air sparging system include an extraction/injection well network, vapor abatement system (if necessary), air compressor or blower, vacuum pump, and associated piping, valves, monitoring and control equipment. The compressor or blower size is typically based on a design maximum expected flow rate and pressure. Each injection well requires pressure measurement and regulation controls to maintain the design operating conditions. Typical well construction materials include metal or PVC piping. Injection well screens are generally 1 to 3 ft in length and must be properly sealed to prevent air flow into the borehole (Hazardous Waste Consultant 1993). Due to the elevated temperature of air leaving the compressor, steel and/or rubber air hose is recommended for the pressurized air distribution system (Hazardous Waste Consultant 1993). Captured vapor will be released to the atmosphere unless an abatement system using carbon adsorption, thermal treatment, or chemical oxidation is used.

In situ air sparging may artificially elevate the water table. This effect should be considered if floating free product is present or if elevating the water table would impact the direction of plume migration.

1.4.3.3 Groundwater Monitoring System. Post-treatment monitoring of nitrate and organic contaminant plumes will be necessary to ensure that established remediation levels have been satisfied. The number and location of monitoring wells required will be determined based on contaminant distribution. Monitoring well design, equipment requirements, and installation are unique due to periodic use and the necessity to obtain representative groundwater samples.

Monitoring wells are typically operated at low, intermittent pumping rates and therefore require much smaller pumps than production-type extraction wells. Wells will be installed to ensure that samples taken are representative and do not include contaminants resulting from materials used for well installation. Also of concern is potential interactions between construction materials and the groundwater being sampled. The design of monitoring wells therefore must specify construction materials that are inert to the chemistry of groundwater being sampled.

1.4.4 Disposal Distances and Location

Wastes requiring disposal include well drilling and construction wastes and vapor treatment wastes. All other treatment processes are in situ treatment techniques, thereby eliminating any other disposal requirements.

1.5 ALTERNATIVE GW-5

Alternative GW-5 has been developed as a removal, treatment, and disposal GRA. The remedial technologies and associated process options that comprise this alternative were initially specified in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a). Based on review of additional information (LFI, 100 Area aggregate studies, treatability testing, and refined RAO), no modifications to this alternative are required. Therefore, the remedial technologies and associated process options are as initially developed:

- removal:
  - extraction wells
- biological treatment:
  - biodenitrification (nitrates)
- chemical treatment:
  - chemical oxidation (organics)
  - precipitation (heavy metals and radionuclides)
  - chemical reduction (hexavalent chromium)

- physical treatment:
    - filtration (remove precipitates and suspended solids)
    - ion exchange (polishing for removal of any remaining ionic contaminants)

- stabilization/solidification:
    - cement-based solidification (secondary waste streams)

- liquid disposal:
    - river discharge or reinjection into an aquifer

- solids disposal:
    - ERDF, W-025, or other site

- monitoring
    - groundwater monitoring.

1.5.1 Objective

The objective of Alternative GW-5 is to contain the contaminant plumes from reaching the river or migrating outside the operable unit and to eliminate source to receptor pathways by removing, treating, and disposing of contaminated groundwater. Alternative GW-5 is designed to remove contaminant plumes from the unconfined aquifer; treat contaminated groundwater to the levels established by remedial action goals; isolate and dispose treatment residuals from the accessible environment; and reinject treated groundwater into the unconfined aquifer or discharge it to the river.

1.5.2 Size and Configuration

Several options are available for implementing groundwater treatment, including a single treatment facility for all contaminated groundwater within the 100 Area or separate treatment facilities for each groundwater operable unit. Although past practices at the 100 Area reactor sites may have resulted in the same contaminants being released to the environment, sampling and analysis indicates the concentrations of contaminants in each operable unit are not the same. Therefore, separate treatment facilities at each operable unit are considered to prevent cross-contamination and enable tailoring treatment systems to specific contaminants of concern at each operable unit.

Pump and treat alternatives have variable life cycles depending on remediation goals and technology performance for specific sites, i.e., the system can run until goals are met or until the technology limitations are met.

1.5.3 Unit Operations

Figure D-3 is a conceptual flow diagram of the unit operations proposed for Alternative GW-5. Each unit operation, equipment requirements and options, and design considerations are described below.

1.5.3.1 Groundwater Extraction System. The below-ground portion of the groundwater extraction system will consist of a series of extraction wells. The extraction wells proposed for removing contaminated groundwater from beneath the 100 Area will be similar to standard production-type water wells used for domestic and industrial applications. The number and location of extraction wells required for each contaminant plume will be determined by hydrologic modeling.

An extraction well consists of vertical borehole tapping the contaminated aquifer. The depth of the well is determined by the vertical extent of contamination and the characteristics of the aquifer. Casing materials would conform to DOE and state requirements for well completions. The casing serves to maintain the borehole integrity and support the pumping mechanism. The well casing is grouted into place so it will not be a conduit for the downward migration of additional contamination.

Extraction wells should be completed using stainless steel, continuous wire-wrapped well screens. The screen prevents sediment uptake and provides support for loose formation material (Driscoll 1986). The screen slot size is specifically designed for the aquifer materials to minimize entrance velocity and prevent the influx of aquifer fines after development. The screened interval of the well must be developed following installation and before it is used for remediation. Development consists of optimizing the flow characteristics of the well screen/aquifer interface by the removal of aquifer fines through surging, over-pumping, or other means.

Any commonly available well pump may be used for extraction of contaminated groundwater. Selection of pump type and power are determined by the response of the aquifer to pumping, the movement of contaminants and the capacity of the remediation system. Typical systems, in order of decreasing capacity and/or pumping depth capability, include:

- line-shaft turbines
- submersible turbines
- jet
- centrifugal
- positive displacement
- peristaltic.

Centrifugal and peristaltic pumps are generally not applicable for suction (i.e., inlet) lifts exceeding 6 m (20 ft) (Driscoll 1986).

The above-ground portion of the groundwater extraction system will consist of a piping network that connects each extraction well to a manifold. From the manifold a single pipeline will bring contaminated groundwater to a storage tank near the treatment area. The storage tank will allow flow equalization and settling of suspended solids that may interfere with subsequent treatment operations. The piping system will be of double-walled construction to ensure leak protection. A single-walled, above-ground storage tank is specified with secondary containment provided by an engineered berm. Pumps, valves, sampling, and monitoring equipment will be specified as needed for the capacity and requirements of the system.

1.5.3.2 Chemical Oxidation System. Chemical oxidation is the initial unit operation proposed for destruction of organic contamination in 100 Area groundwater. Groundwater and reagents, such as hydrogen peroxide and ozone, are pumped into a process vessel where organic contaminants are oxidized (the reaction may be enhanced by ultraviolet light). A simplified reaction (for a hydrocarbon) of this process is:

$$C_xH_y + H_2O_2/O_3 \xrightarrow{uv} xCO_2\uparrow + \frac{Y}{2}H_2O$$

Groundwater entering the chemical oxidation system is filtered to remove suspended solids. Two cartridge filters arranged in parallel are specified for this application to allow for continuous operation during maintenance or filter replacement. After filtration the oxidizing reagent is combined with the groundwater and passed through a static mixer to ensure the feed into the oxidation reactor is homogeneous. A static mixer is selected for this application for simplicity, as such a unit has no moving parts and requires no maintenance or operating costs.

Once the groundwater and reagents have been combined, the mixture is fed into the oxidation reactor vessel. Inside the reactor this mixture is exposed to ultra violet lamps that catalyze the oxidation process. Organic contaminants are oxidized to form carbon dioxide and water (assuming 100% reaction efficiency). A hydrochloric acid scrubber is required if chlorinated organics are present[2]. An acid or base may be required to adjust pH before and after the oxidation reactor to optimize the efficiency of oxidizing organic contaminants (EPA 1993).

1.5.3.3 Precipitation System. Following chemical oxidation, chemical precipitation is proposed to remove radionuclides and heavy metals. In general, metal contaminants can be precipitated from solution as hydroxides, sulfides, carbonates, or other insoluble salts (EPA 1987). Common precipitation reagents include lime, caustics such as sodium hydroxide, sulfides such as sodium bisulfide, ferrous sulfide, calcium carbonate, and sodium carbonate (Corbitt 1990). However, because contaminant concentrations are so dilute, most of the precipitating species will consist of common water minerals. Common methods for precipitation involve addition of precipitation reagents or pH adjustment.

[2]Hydrochloric acid is a byproduct of oxidation of chlorinated organics.

Specification of precipitation reagents and pH is contaminant dependent. A precipitation reaction resulting in the formation of an insoluble form of strontium-90 occurs as described by the following simplified reaction:

$$^{90}Sr + CO_3 \rightarrow {}^{90}SrCO_3 \downarrow$$

A conceptual chemical precipitation process consists of a mixing tank, a reagent feed system, and a clarifier tank. Associated piping, pumps, valves, and monitoring and control equipment complete the equipment requirements. The process stream and precipitation reagents are combined in a continuously stirred continuous flow (CSCF) reactor vessel. The mixture is then pumped to the clarifier tank where the resulting insoluble salts are separated from the process stream as a concentrate. The process stream or overflow from the clarifier is then pumped to chromium reduction process.

The concentrate from the CSCF reactor is pumped to a rotary drum filter for dewatering. A filtration media such as diatomaceous earth is added to the concentrate to facilitate the filtration process. The resulting filter cake is collected and transported to the solidification system. The liquid effluent from dewatering is combined with the process stream from the clarifier for subsequent treatment in the chromium reduction process.

1.5.3.4 Chromium Reduction System. Following chemical precipitation unit operations, chromium reduction is proposed to reduce hexavalent chromium. Hexavalent chromium can be reduced from the soluble hexavalent state to the less soluble trivalent state (pH ≤ 3) and precipitated under basic conditions (pH of 8 to 9) (Corbitt 1990). Chromium may also be reduced by reaction with reagents such as sulfur dioxide, sulfite salts (such as sodium metabisulfite), and ferrous sulfate (Corbitt 1990). Hexavalent chromium can be reduced by reacting with sulfur dioxide and then precipitated as a hydroxide according to the following reactions:

$$Cr_2O_7^{2-} + 6Fe^{2+} + 6SO_4^{2-} + 14H^{+} \rightarrow 2Cr^{3+}(SO_4^{2-})_3 \downarrow + 6Fe^{3+}$$

The chemical reduction process is similar to the chemical precipitation process described previously. Separate process equipment is required to perform chemical reduction because of the conditions and reagents under which the required reaction occurs. The process stream, reducing agent, and precipitation reagent are combined in a CSCF reactor vessel. The mixture is then pumped to the clarifier tank where the resulting insoluble salt is separated from the process stream as a concentrate. The process stream or overflow from the clarifier is then pumped to the biodenitrification system.

The concentrate from the CSCF is pumped to a rotary drum filter for dewatering. A filtration media such as diatomaceous earth is added to the concentrate to facilitate the filtration system. The resulting filter cake is transferred to the solidification process to be prepared for disposal. The liquid effluent from dewatering is combined with the process stream from the clarifier for subsequent treatment in the biodenitrification system.

1.5.3.5 Biodenitrification System. Following chemical reduction, biodenitrification is proposed to reduce nitrates to elemental nitrogen. The growth of microorganisms is dependent on the availability of nutrients and a carbon source (Corbitt 1990). In the denitrification process, bacteria use nitrates as an electron acceptor. Denitrification occurs according to the following simplified reaction:

$$NO_3^{-1} \xrightarrow{\textit{Bacterial Metabolic Process}} N_2\uparrow$$

The biodenitrification treatment process requires a feed system, reactor vessel, clarifier, and monitoring and control equipment (Brouns et al. 1991). Piping, pumps, and valves are required as needed for the capacity requirements of the system.

The feed system adds nitrate contaminated groundwater plus a carbon source, such as acetate or methanol, into a reactor vessel. Depending on the type of bioreactor, recycling biomass or growth of the original culture will preclude the need for addition of bacteria. Off-gas chemistry, pressure, temperature, and pH are monitored to control the denitrification process.

Bioreactors are generally classified into two categories: suspended-growth systems and fixed-growth systems (Corbitt 1990). Suspended-growth systems, such as a continuously stirred-tank bioreactors (CSTR), or fixed-growth systems, such as a fluidized-bed bioreactors (FBR), can be used for denitrification applications (Brouns et al. 1991). The CSTR vessel mixes contaminated groundwater with suspended biomass to maximize contact between contaminants and microorganisms. The FBR vessel contains biomass attached to a support media, such as anthracite coal. Contaminated groundwater passes through the support media where nitrate contaminants contact microorganisms.

Effluent from the reactor vessel is sent to a settling tank. In the case of the CSTR, suspended biomass is removed for recovery and recycled back into the reactor. The settling tank clarifies the effluent for subsequent processing in the ion exchange process.

1.5.3.6 Ion Exchange System. Following biodenitrification, ion exchange is proposed to remove radionuclides not readily precipitated (either by pH adjustment or by redox), such as cesium-137 and technetium-99. The ion exchange process is the final unit operation applied to contaminated groundwater prior to reinjection into an aquifer. Both cation and anion exchange resins are proposed to ensure removal of any contaminants that may still remain in trace concentrations. The proposed ion exchange process consists of media filtration followed by separate cation and anion exchange columns, and a resin regeneration loop.

The performance of ion exchange resins will be impaired by the presence of suspended solids, bacteria, colloids, or oily materials in the feed stream (Corbitt 1990, Moghissi et al. 1986). Therefore, the process design specifies that the feed stream is filtered prior to entering the exchange columns. Two cartridge filters arranged in parallel are specified for this application to allow for continuous operation during maintenance or filter replacement. Pressure monitoring equipment is required to identify when replacement is necessary due to particulate loading.

The proposed ion exchange design will utilize a separate-bed system as opposed to a mixed-bed system in order to facilitate resin regeneration. The separate-bed system involves two vessels arranged in series. The first vessel containing the cation exchange resin and the second vessel containing the anion exchange resin. The separate-bed system is preferred for removing specific radionuclides (Moghissi et al. 1986). Similar to the cartridge filter design, two separate-bed systems may be arranged in parallel to allow for continuous operation during maintenance, regeneration, or resin replacement.

Specification of ion exchange resins for this process will depend on the type of contaminants to be removed, the contaminant concentration remediation levels, and the presence of other ions in the feed stream that may interfere with the efficiency of removing contaminants (Corbitt 1990). There are four general types of ion exchange resins that include strong- and weak-acid cation resins and strong- and weak-base anion exchange resins (Corbitt 1990). Ion specific exchange resins are available for isotopes of Cs^{+}, Co^{+2}, Sr^{+2}, and Mn^{+2} (Moghissi et al. 1986). Ion-selective exchange resins can be used to remove any one or more these specific contaminants. Selective resins are typically zeolite and glass-based materials. The primary benefit of ion-selective exchange resins is a reduction in the amount of resin spent on removing ions from the process stream that are not of concern.

Strong-acid cation and strong-base anion exchange resins have a low regeneration efficiency (Moghissi et al. 1986). Therefore, regeneration of these resins can result in large quantities of regenerative waste. Conversely, weak-acid cation and weak-base anion exchange resins can be regenerated with near stoichiometric quantities of regenerants (Moghissi et al. 1986). Another option is a chabazite zeolite cation exchange resin. The zeolite resin is nonregenerable and would be discarded after loading. The benefit from using the zeolite resin is that it is not regenerated and thus no liquid regeneration wastes are generated. The only waste product is the contaminated solid zeolite. These once-through zeolites are economical because the secondary waste is a solid waste rather than a liquid waste which must be further processed (at considerable additional cost).

A regeneration loop is included in the ion exchange process to maximize the life of the ion exchange resins. A design variation may avoid regeneration by specifying disposal of spent resins (e.g., chabazite zeolite); however, regeneration is assumed in this application for conservatism. Monitoring the conductivity of the effluent from each ion exchange vessel will identify when the resins will require regeneration. Regeneration is accomplished by stripping contaminant ions from exhausted resin beds with concentrated acid, caustic, or other reagent solutions. In this process, contaminant cations are replaced with innocuous cations, such as hydronium (H^{+}), and contaminant anions are replaced with innocuous anions, such as hydroxide (OH^-) (Corbitt 1990). The equipment requirements to perform regeneration include acid and caustic storage tanks, regenerative waste storage tank, and any associated piping, pumps, valves, and monitoring equipment.

The regeneration loop results in secondary liquid waste requiring solidification prior to disposal. Therefore, liquid regenerative wastes will be sent to a cement-based solidification process.

1.5.3.7 Cement-Based Solidification System. Cement-based solidification is proposed for all liquid-, sludge-, or slurry-type waste streams generated as a result of treating contaminated groundwater prior to disposal in the 200 Area. Secondary waste streams such as spent ion exchange resins may or may not require solidification prior to disposal depending on the requirements of the ERDF or other site waste acceptance criteria. The secondary waste streams generated from each treatment process are summarized in Table B-1.

Cement is the most commonly used material for solidification of radioactive wastes (DOE 1988). The types of cement used for waste solidification are Portland cement, masonry cement, and gypsum (DOE 1988). Special additives have been developed to enhance the capabilities of cement-based solidification such as waste loading, contaminant leachability, compressive strength, and setting characteristics.

Filter cake, ion exchange resins, and decontamination solutions are compatible with cement-based solidification (DOE 1988). However, cement-based solidification of each secondary waste stream generated from treatment of 100 Area groundwater is likely to require development of separate recipes or formulations. Differences in cement formulations may require separate solidification systems for each secondary waste stream or batch processing each secondary waste stream separately. The equipment requirements for cement-based solidification depend on pretreatment requirements, physical form, and waste volume.

Pretreatment such as pH adjustment of liquid wastes may be required. Resin regenerative wastes may require addition of an acid or caustic for pH adjustment prior to solidification. The physical form of secondary wastes will influence equipment specifications for items such as piping, pumps, and storage tanks for liquids. Conveying equipment and storage bins or silos may also be required.

The volume of secondary wastes generated will be used to determine whether solidification can be accomplished directly within containers or whether larger more complex mixing equipment is required. In-container mixing processes are generally applicable to small volume waste streams. These processes involve simply adding cement and waste (in predetermined proportions) directly into the disposal container and mixing. Mixing can be accomplished by placing a mixing weight into the container, sealing the container, and then using a drum tumbler or shaker until the contents are thoroughly mixed. Motor driven mixing rods are available in which the mixing rod can be either reused or simply left in the container (DOE 1988).

Large volume waste streams require mixing waste and cement in large vessels. This type of system consists of storage tanks for liquid wastes, feed hoppers for solid wastes and dry materials such as cement and additives. Waste, cement, and water (if necessary) are combined in larger mixing vessels. The resulting mixture is then metered and fed into disposal containers. This type of solidification process enables continuous processing or may be used on a batch-type basis.

Secondary waste streams which do not require solidification in cement, such as filter cartridges, will be packaged directly into disposal containers and transported to ERDF, W-025, or another site.

1.5.4 Disposal Distances and Location

1.5.4.1 Liquid Disposal. Treated groundwater is the only liquid effluent generated by this alternative and it will be discharged to the Columbia River or reinjected to the aquifer. The treatment train described above treats the groundwater for every contaminant except tritium (no practicable treatment is currently available for tritium). The tritium levels in most plumes in the 100 Area are already below the MCL, thus the water can be discharge directly to the river. However, if tritium levels in the effluent exceed the MCL, then the effluent cannot be discharged to a surface water (i.e., it doesn't meet drinking water standards).

Effluent contaminated by tritium above the MCL will be reinjected into the groundwater. This establishes an extraction/injection loop which allows time for natural radioactive decay of the tritium. The injection point can be chosen such that the travel time to the river is sufficient for the tritium to radioactively decay below the MCL before reaching the river. Both river discharge and reinjection process options are discussed below.

1.5.4.1.1 River Discharge. The treated water will be collected in a surge tank to determine if is below MCL for the contaminants. If so, the treated water will be directed to the river via a buried gravity flow pipeline. It is assumed that the flow would be routed via an existing river outfall or a new outfall. An analysis of the condition of existing pipelines and outfalls would be required prior to implementation.

River discharge may require an National Pollutant Discharge Elimination System (NPDES) permit. Although some outfalls have been operating under existing NPDES permits, additional permitting requirements, if any, have not yet been established for river disposal of treated water. Establishing permitting requirements would require discussions with regulators. In addition, the Tri-Party Agreement Milestone M-17 requiring cessation of liquid effluent discharges by 1995 may affect treated water disposal options.

1.5.4.1.2 Reinjection System. Following treatment, effluent with tritium levels above MCL is to be reinjected into the aquifer beneath the 100 Area. The number and location of injection wells will be determined on the basis of hydrologic modeling and required flow rates. Design, installation, and equipment requirements for such an injection system will similar to the equipment described previously for extraction wells. Treated groundwater will be pumped in a single pipeline. At the injection point, a manifold will be used to feed the treated groundwater to each injection well.

The primary design considerations involved with injection wells are efficiency and well life (Driscoll 1986). The efficiency of an injection well is dependent on the selection and location of the screen. The well screen should be located in the area of the aquifer and/or vadose zone that has the greatest hydraulic conductivity. Screen openings should be as large as possible such that treated groundwater can enter the formation without excessive pressure build-up. Material selection can be an important consideration for ensuring adequate well life. However, due to the quality of treated groundwater exiting the ion exchange process, this should not be a major concern.

1.5.4.2 Disposal of Solidified Residues. Solid wastes generated as a result of treating contaminated groundwater are disposed in the 200 Area ERDF (approximately 9 miles from the 100 Area). Solidified waste is transported by truck to the 200 Area for disposal. Radioactive and mixed secondary waste will meet ERDF acceptance criteria.

1.5.5 Groundwater Monitoring

Post-treatment monitoring of 100 Area groundwater will be necessary to ensure that established remediation levels have been satisfied and additional sources of contamination are not discovered. The number and location of monitoring wells required will be determined based on contaminant distribution. Monitoring well design, equipment requirements, and installation were described previously under Alternative GW-4.

1.6 ALTERNATIVE GW-6

Alternative GW-6 has been developed as a removal, treatment, and disposal general response action. The remedial technologies and associated process options initially specified for this alternative in the 100 Area FS Phases 1 and 2 (DOE-RL 1994a) have been significantly modified. The biodenitrification and ion exchange processes initially specified have been determined to be redundant and no longer necessary. This determination is based on the capabilities of reverse osmosis for removing contaminants applicable to biodenitrification and ion exchange treatment. Based on these modifications, Alternative GW-6 now consists of the following remedial technologies and associated process options:

- removal:
  - extraction wells

- physical treatment:
  - air stripping/carbon adsorption (organics)
  - filtration (remove suspended solids)
  - forced evaporation (for volume reduction prior to solidification)
  - reverse osmosis (high molecular weight inorganic contaminants)

- stabilization/solidification:
  - cement-based solidification (secondary waste streams)

- liquid disposal:
  - crib disposal

- solids disposal:
  - ERDF

- monitoring
  - groundwater monitoring (100 Area groundwater).

1.6.1 Objective

The objective of Alternative GW-6 is identical to that described previously for Alternative GW-5. Source to receptor pathways are to be eliminated by complete removal, treatment, and disposal of contaminants in the 100 Area. Alternative GW-6 satisfies this objective in the same manner as Alternative GW-5 except for the methods of treatment. Alternative GW-6 is designed to remove contaminant plumes from the unconfined aquifer; treat contaminated groundwater to the levels established by remedial action goals; isolate and dispose treatment residuals from the accessible environment; and dispose treated groundwater by reinjection to the unconfined aquifer or to the river.

1.6.2 Size and Configuration

Alternatives GW-6 and GW-5 are similar in that both alternatives are developed as removal, treatment, and disposal general response actions. The primary difference between these alternatives is the treatment technologies specified to achieve remedial action objectives. The aspects of alternative GW-6 that are differ from alternative GW-5 are summarized below:

- biological treatment - no biological treatments are specified in GW-6
- chemical treatment - no chemical treatment are specified in GW-6
- physical treatment - only physical treatments are specified in GW-6
- disposal - crib disposal.

The primary components of the unit operations required for alternative GW-6 are presented schematically in Figure D-4.

1.6.3 Unit Operations

Figure D-4 is a conceptual flow diagram of the unit operations proposed for Alternative GW-6. As noted previously, the biodenitrification and ion exchange unit operations initially specified for this alternative in the 100 Area FS Phases 1 and 2

(DOE-RL 1994a) are no longer included. In addition, the location within the treatment train initially specified for the evaporator has also been changed. Since operable unit-specific treatment processes are being considered as opposed to a single 100 Area treatment facility, the primary purpose of the evaporator has changed from volume reduction of groundwater entering the treatment system to volume reduction of liquid effluent from the reverse osmosis process. Unit operations, equipment requirements and options, and design considerations are described below.

1.6.3.1 Groundwater Extraction System. The groundwater extraction system proposed for Alternative GW-6 is identical to the system described for Alternative GW-5. Refer to the description presented previously for Alternative GW-5 for details.

1.6.3.2 Air Stripping/Carbon Adsorption. Air stripping followed by carbon adsorption is the initial series of unit operations proposed in this alternative for treating 100 Area groundwater. This process removes low concentrations of VOC from contaminated groundwater. Due to the extent and type of organic contamination in 100 Area groundwater, the process would be required only on an as needed basis. Air stripping is generally applicable to dilute aqueous wastes with VOC concentrations less than approximately 100 mg/L (Freeman 1989). The VOC are removed from groundwater by countercurrent gas-liquid desorption. Once removed from the groundwater, VOC can then adsorbed onto activated carbon.

Groundwater entering the process is filtered to remove suspended solids. Two cartridge filters arranged in parallel are specified for this application to allow for continuous operation during maintenance or filter replacement. After filtration, groundwater is pumped to the air stripper.

Several air stripper designs are currently available, however, the most common or conventional air strippers are vertical towers filled with a packing media. In this design contaminated water enters the top of the tower and falls by gravity through the packing media to a collection sump. Simultaneously, uncontaminated air enters from the bottom of the tower and is discharged at the top. The packing media maximizes the liquid surface area exposed to air flowing countercurrent to the liquid. Depending on water quality, packed-tower air strippers can be susceptible to fouling from scaling or solids deposition.

Newer designs involve low-profile air strippers which are essentially diffused aerators that bubble air up through a chamber filled with contaminated water (Reese 1992). Low-profile air strippers offer several advantages over conventional packed-tower designs: reduced potential for fouling; less maintenance requirements; and higher efficiency at lower contaminant concentrations. However, the low-profile design uses higher air/water ratios that require higher horsepower blowers and result in increased off-gas volume requiring treatment.

Liquid effluent from the air stripper is pumped to the reverse osmosis system for inorganic contaminant removal while VOC laden off-gas is treated in carbon adsorption units. Two carbon beds in parallel are placed in series with one polishing carbon bed for removing VOC from the air stripper off-gas. Vapor phase carbon adsorption beds are available in disposable canisters or larger reusable vessels. Large activated carbon beds can be regenerated or disposed once saturated with contaminants. Treated air is discharged to the atmosphere.

1.6.3.3 Reverse Osmosis System. Following the organics treatment system, reverse osmosis is proposed to remove soluble inorganic contaminants, especially those of higher molecular weight. Reverse osmosis is a cross-flow membrane separation process that purifies contaminated water by application of high pressure which forces pure water through a semipermeable membrane, but leaves the contaminants in a concentrated waste stream (EPA 1987). The process is commercially available and highly effective for purifying water containing dissolved ions and radionuclides. However, a chief disadvantage is the generation of a substantial volume of secondary liquid waste that must be volume reduced and solidified prior to disposal.

Reverse osmosis membranes are typically either spiral wound into a cylindrical configuration or are fabricated into hollow fibers. The membranes provide a pore size in the range of one to ten angstroms (0.0001 - 0.001 microns). There are essentially three types of reverse osmosis membranes: cellulose acetate, aromatic polyamides, and thin-film composites (Freeman 1989). The thin-film composite type membranes are generally considered to be the most effective.

An reverse osmosis system may consist of three separate components. The first component in the system provides pretreatment of the feed stream to comply with the reverse osmosis membrane manufactures specifications. The second component is the reverse osmosis treatment vessel which, depending on the final system design, may consist of multiple reverse osmosis vessels. The third component provides post-treatment to the purified effluent to meet reuse standards or to prepare for additional treatment. The third component is not considered applicable to this system as any treatment required for additional unit operations will be considered pretreatment for that particular system.

Pretreatment requirements are based on the type and manufacturer of the reverse osmosis membrane specified and the condition of the feed stream. If necessary, pretreatment will maximize reverse osmosis membrane operating efficiency and reduce the potential for fouling. Pretreatment requirements may include (Porter 1990, Freeman 1989, Moghissi et al. 1986):

- elimination of suspended solids 1 micrometer or larger
- pH adjustment to between 4 and 6
- addition of precipitation inhibitors
- removal of oxidizing compounds
- elimination of organic contaminants
- temperature elevation.

The reverse osmosis portion of the system consists primarily of a high pressure pump, reverse osmosis module (containing the reverse osmosis membrane), piping, valves, and control and monitoring equipment. The high pressure pump pressurizes feed water to above osmotic pressures such that the reverse osmosis phenomenon occurs. The reverse osmosis module contains the membrane packaging and is categorized into four possible designs: plate and frame, spiral-wound, tubular, and hollow fine fiber (Porter 1990). The tubular design reverse osmosis module is least susceptible to fouling, has the highest tolerance to suspended solids, and has the possibility of mechanical membrane cleaning (Porter 1990).

1.6.3.4 Evaporation System. Following the reverse osmosis process, forced evaporation is proposed to reduce the volume of reverse osmosis concentrate requiring cement solidification. Depending on the type of evaporation system specified, concentrations of up to 50% total solids can be achieved (DOE 1988). Evaporation technology has been used for liquid radioactive waste treatment for several decades (Moghissi et al. 1986). The evaporation process involves the use of heat to vaporize water, thereby leaving a concentrated solution containing nonvolatile contaminants. The resulting concentrated solution requires additional treatment while vaporized water is simply condensed and sent for disposal.

Evaporators generally fall into one of two categories, either natural circulation or forced circulation. Natural or forced refers to the way in which liquid waste is circulated through the heat exchanger and vapor body. Natural circulation evaporators include rising-film and fixed-film types. Forced circulation evaporators include evaporative crystallizer, wiped-film, and extruder types. The evaporative crystallizer is the most commonly used evaporator for radioactive waste applications (DOE 1988).

Forced circulation evaporators have proven to be more effective in concentrating solids than natural circulation evaporators (DOE 1988). In addition, forced circulation evaporators allow separation of the heat transfer, vapor-liquid separation, and crystallization functions (Moghissi et al. 1986), thereby facilitating maintenance operations.

Evaporator energy requirements can be substantially reduced by recycling heated vapor generated by the evaporator back into the heat exchanger to facilitate evaporation of additional feed waste. Not only is the energy stored in the steam reused to heat feed waste, but the need for a condenser is eliminated. This process is commonly referred to as vapor recompression. Vapor recompression can reduce energy consumption by up to 80% (DOE 1988).

The evaporation system specified for application to Hanford 100 Area groundwater is the forced circulation, evaporative crystallizer with mechanical recompression. Due to the low capacity of typical evaporators, multiple evaporators may be required. Each evaporator system consists of a heat exchanger, vapor body (or flash chamber), recirculation pump, entrainment separator, and condenser (or compressor for recompression). Associated piping, valves, feed and effluent pumps, and control and monitoring equipment will be required as needed.

Concentrate from the evaporator is fed to a rotary vacuum drum filter for dewatering. A filtration media such as diatomaceous earth is added to the concentrate to facilitate the filtration process. The resulting filter cake is collected in a hopper which can be transported with industrial equipment such as a forklift to the solidification system. Liquid effluent from the rotary drum filter is recirculated back into the feed stream entering the reverse osmosis system.

1.6.3.5 Cement-Based Solidification System. As described previously for Alternative GW-5, cement-based solidification is proposed for liquid-, sludge-, or slurry-type waste streams generated as a result of treating contaminated groundwater (see Table D-2). Solidified wastes will be transported to the 200 Area for disposal. The secondary waste streams generated from each treatment system are summarized as follows:

The secondary waste streams generated by the treatment systems proposed for Alternative GW-6 are similar to those generated from the Alternative GW-5 treatment systems. Those secondary waste streams unique to Alternative GW-6 include fouled packing material from the air stripping tower, spent activated carbon beds, and fouled reverse osmosis membranes from the carbon adsorption units. Secondary waste streams in solid form such as filter cartridges, air stripper packing material, spent carbon, and fouled reverse osmosis membranes, will generally be packaged directly into containers suitable for disposal. However, if solidification is required for any of these materials (based on ERDF requirements), size reduction may be necessary to ensure complete encapsulation in cement.

The cement solidification system and materials described previously for Alternative GW-5 would be identical to the cement solidification system requirements for this alternative. In general, the applicable secondary waste streams will be pretreated (if necessary), mixed with cement, and placed in Department of Transportation (DOT) approved containers. After the appropriate curing time has elapsed, solidified wastes will be transported by truck to the ERDF for disposal.

1.6.4 Disposal Distances and Location

1.6.4.1 Liquid Disposal. Disposal of liquid effluents generated by implementation of Alternative GW-6 is nearly identical to the previous discussion for Alternative GW-5. Surface discharge into cribs is specified for Alternative GW-6 as opposed to the reinjection/river discharge technique specified for Alternative GW-5.

1.6.4.2 Disposal of Solidified Residues. Disposal of solidified waste generated by implementation of Alternative GW-6 is identical to the previous discussion for Alternative GW-5.

1.6.5 Groundwater Monitoring

As described previously in Alternative GW-5, post-treatment monitoring of 100 Area groundwater will be necessary to ensure that established remediation levels have been satisfied and additional sources of contamination are not discovered. The number and location of monitoring wells required will be determined based on contaminant distribution. Monitoring well design, equipment requirements, and installation are the same as described previously in Alternative GW-4.

Figure D-1 Conceptual Vertical Barrier Alternative GW-3

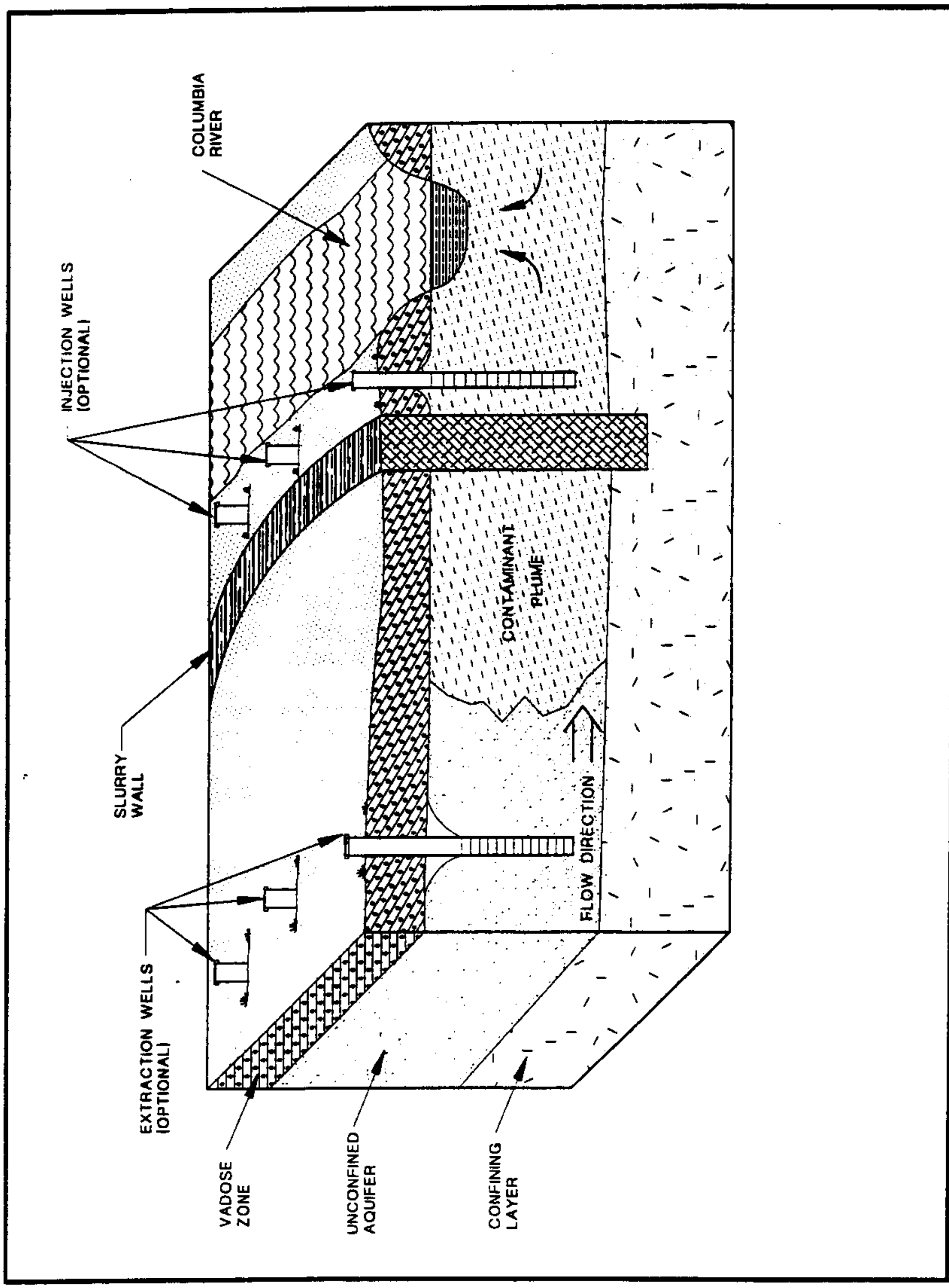
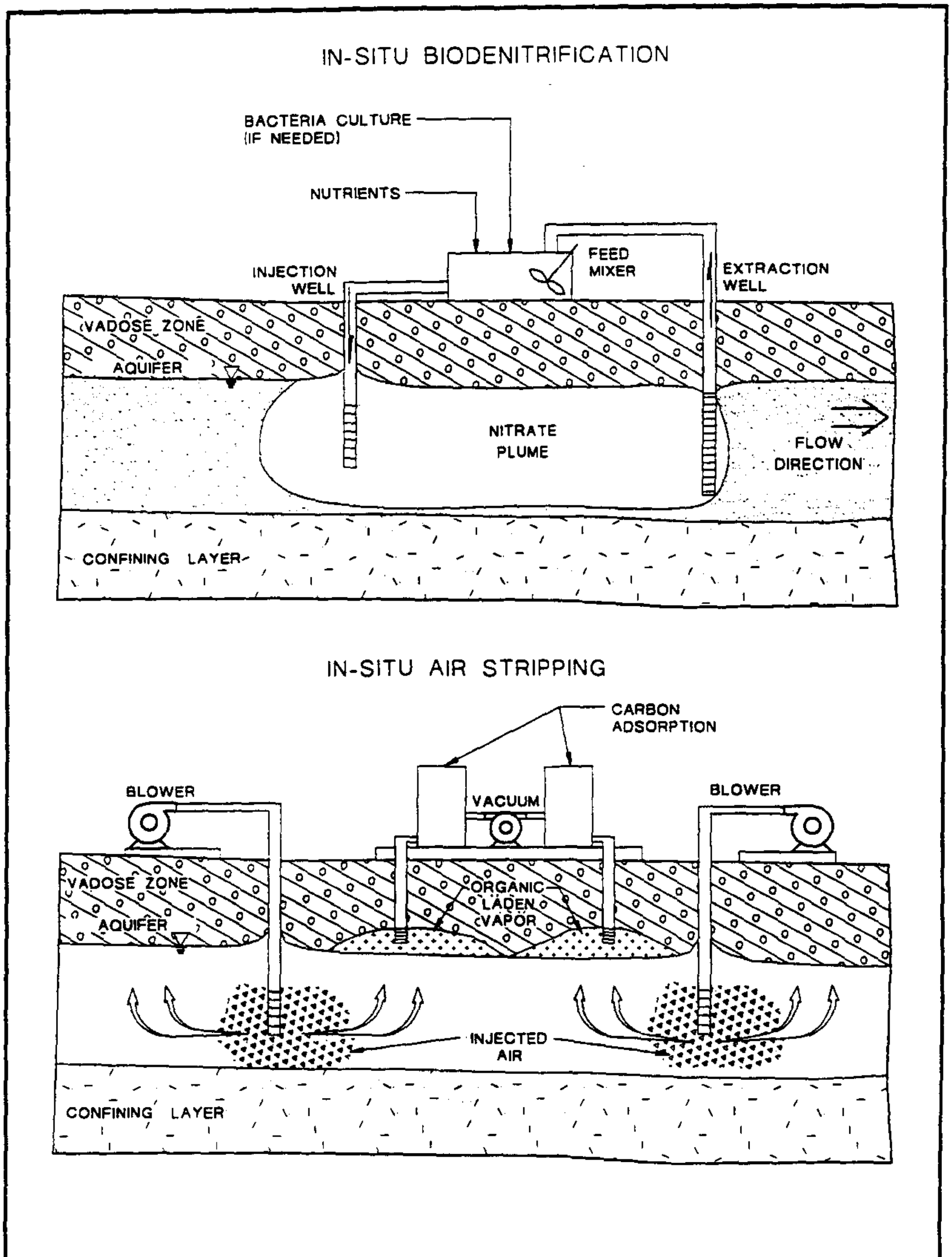


Figure D-2 Conceptual In Situ Treatment Alternative GW-4



BIOSTRIP 05/19/94

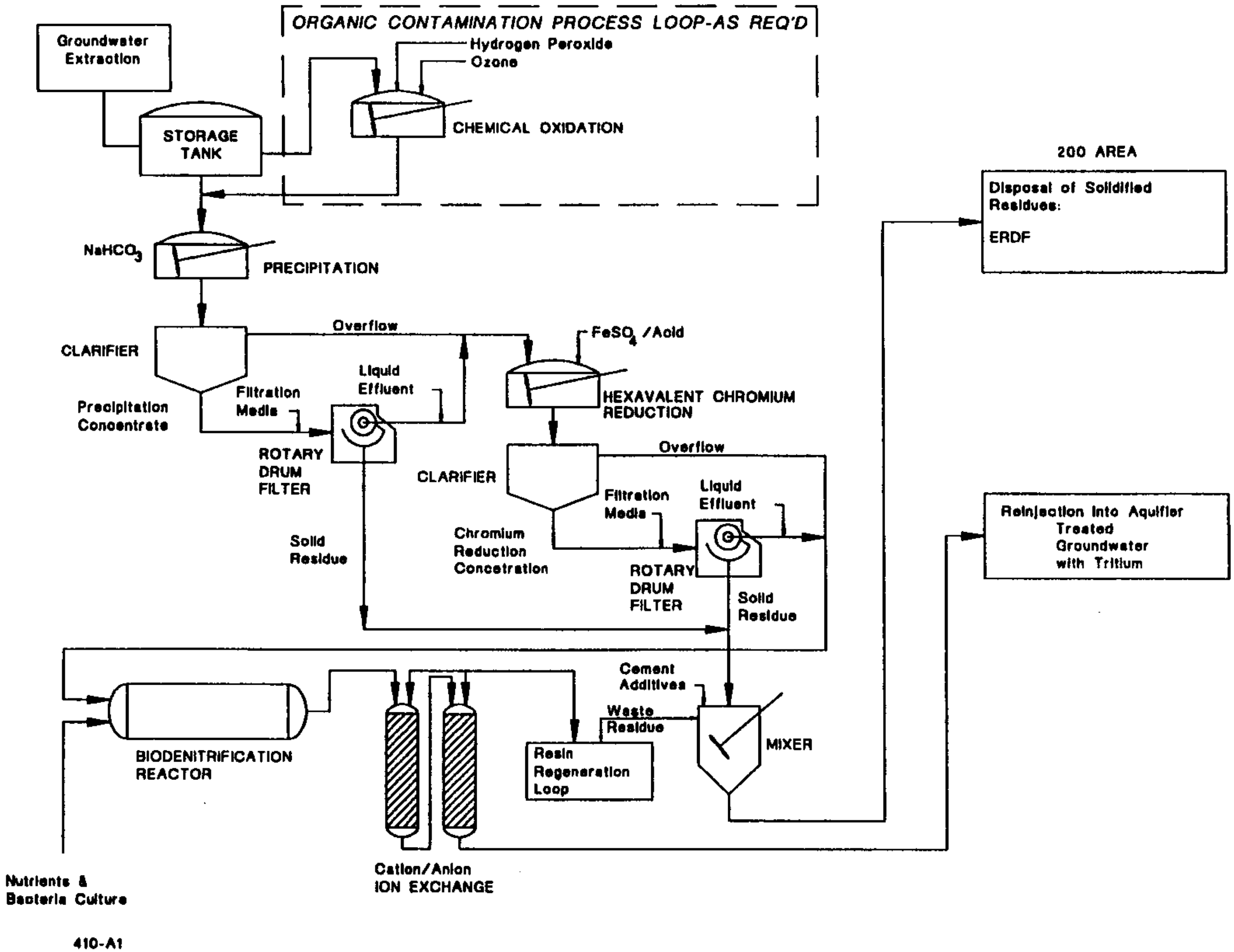


Figure D-3 Conceptual Ion Exchange Treatment System for Alternative GW-5

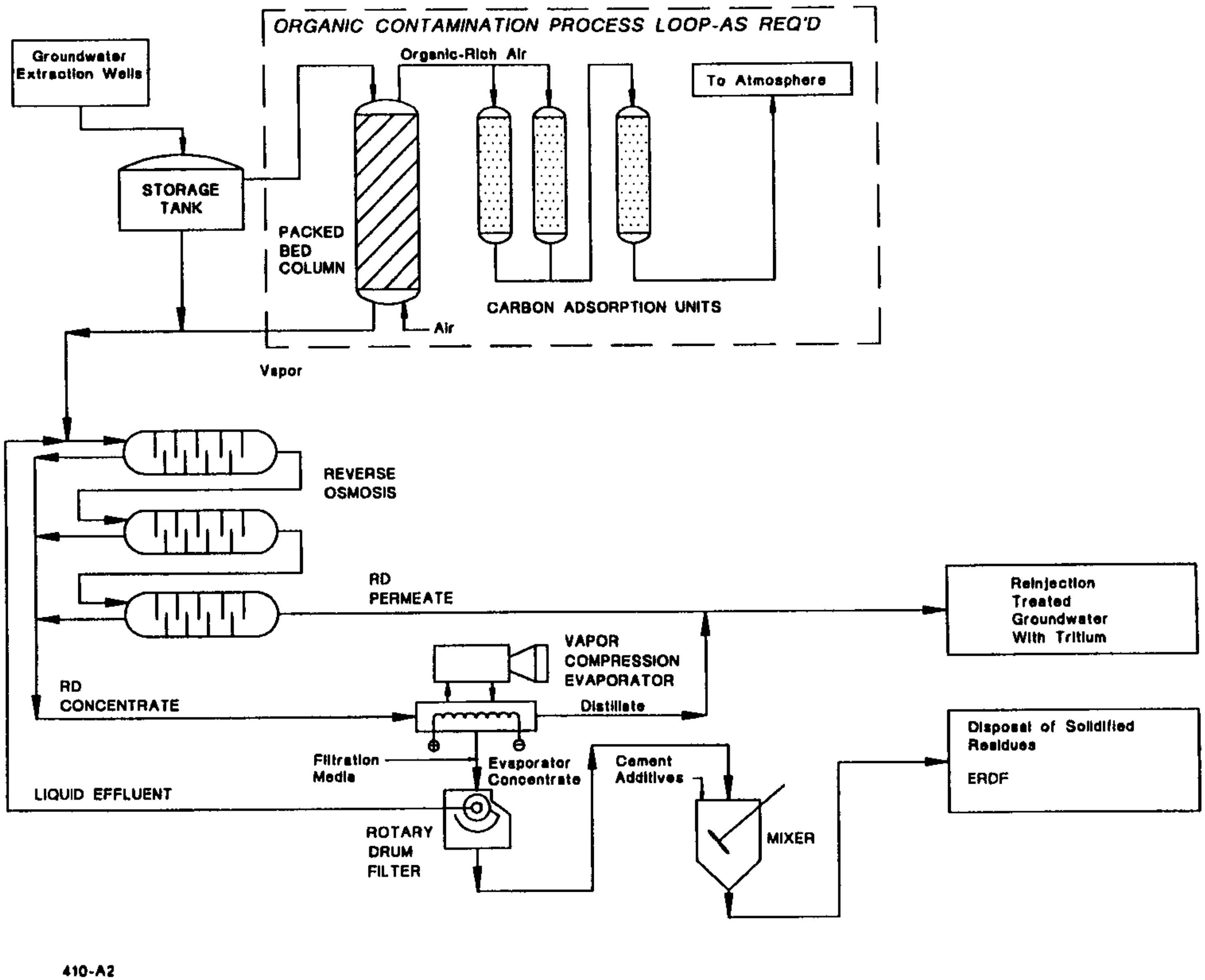


Figure D-4 Conceptual Reverse Osmosis Treatment System for Alternative GW-6

Table D-1 Secondary Waste Streams for Alternative GW-5

Treatment Process	Description	Physical Form
Equalization storage tank	Tank bottoms	Sludge
Chemical oxidation	Filter cartridges	Solid
Chemical precipitation	Rotary drum filter cake	Filter cake
Chemical reduction	Rotary drum filter cake	Filter cake
Biodenitrification	Clarifier concentrate	Slurry
Ion exchange	Filter cartridges	Solid
	Spent ion exchange resins	Solid
	Regenerative waste	Slurry

Table D-2 Secondary Waste Stream for Alternative GW-6

Treatment Process	Description	Physical Form
Equalization storage tank	Tank bottoms	Sludge
Air stripping	Filter cartridges	Solid
	Fouled packing	Solid
	Activated carbon	Solid
Reverse osmosis	Fouled membranes	Solid
Evaporator	Rotary drum filter cake	Filter cake

APPENDIX E

COST MODELS

1.0 COST MODEL DETAILS AND ASSUMPTIONS

This appendix presents the cost estimate details for the 100-BC-5 FFS. Included are assumptions and other criteria used to establish costs of implementing each remedial alternative. Four subsections are provided that include:

Section 1.1 Present Worth Tables
Capital expenditures and operation and maintenance costs are tabulated by year and linked with the discount factors to arrive at a present worth for that remedial technology. Dollar amounts for capital and operation and maintenance are taken from Cost Summary Sheets provided in Section 1.3.

Section 1.2 Cost Model Assumptions
Included are assumptions for each remedial alternative by task/subtask/sub-subtask. The source for costs associated with the task/subtask/sub-subtask assumption(s) are also provided.

Section 1.3 Cost Summary Sheets
The cost summary tables provide a link between the remedial alternative cost models and their respective present worth. It is here that capital and operation and maintenance costs are summed by year for subsequent entry into the present worth tables.

Section 1.4 Remedial Alternative Cost Models
Cost elements of each remedial alternative are listed by task/subtask/sub-subtask using the MCACES cost model software. Additional details such as lineal feet of pipe, pump size, and flow capacity of equipment are also included.

Adders such as tax, project management costs, and contingencies are introduced into the remedial alternative cost at this stage.

SECTION 1.1 PRESENT WORTH TABLES

PRESENT WORTH CALCULATIONS

100-BC-5: INSTITUTIONAL CONTROLS/CONTINUED CURRENT ACTIONS

ANNUAL DISCOUNT RATE = 5%

YEAR	CAPITAL COST	O&M COST	DISCOUNT FACTOR	ANNUAL EXPENDITURE	PRESENT WORTH
0	$0	$0	1.0000	$0	$0
1	$0	$112,678	0.9524	$112,678	$107,315
2	$0	$82,598	0.9070	$82,598	$74,916
3	$0	$82,598	0.8638	$82,598	$71,348
4	$0	$82,598	0.8227	$82,598	$67,953
5	$0	$82,598	0.7835	$82,598	$64,716
6	$0	$82,598	0.7462	$82,598	$61,635
7	$0	$82,598	0.7107	$82,598	$58,702
8	$0	$82,598	0.6768	$82,598	$55,902
9	$0	$82,598	0.6446	$82,598	$53,243
10	$0	$82,598	0.6139	$82,598	$50,707
11	$0	$82,598	0.5847	$82,598	$48,295
12	$0	$82,598	0.5568	$82,598	$45,991
TOTALS	$0	$1,021,256			$760,723

TOTAL COST OF THE ALTERNATIVE: ***$760,723***

PRESENT WORTH CALCULATIONS

100-BC-5: VERTICAL BARRIER ALTERNATIVE (SLURRY WALL)

ANNUAL DISCOUNT RATE = 5%

	YEAR	CAPITAL COST	O&M COST	DISCOUNT FACTOR	ANNUAL EXPENDITURE	PRESENT WORTH
	0	$7,998,790	$0	1.0000	$7,998,790	$7,998,790
	1	$0	$1,088,113	0.9524	$1,088,113	$1,036,319
	2	$0	$1,056,393	0.9070	$1,056,393	$958,148
	3	$0	$1,115,523	0.8638	$1,115,523	$963,589
	4	$0	$1,056,393	0.8227	$1,056,393	$869,095
	5	$0	$1,056,393	0.7835	$1,056,393	$827,684
	6	$0	$1,115,523	0.7462	$1,115,523	$832,403
	7	$0	$1,056,393	0.7107	$1,056,393	$750,779
	8	$0	$1,056,393	0.6768	$1,056,393	$714,967
	9	$0	$1,115,523	0.6446	$1,115,523	$719,066
	10	$0	$1,056,393	0.6139	$1,056,393	$648,520
	11	$0	$1,056,393	0.5847	$1,056,393	$617,673
	12	$28,860	$1,056,393	0.5568	$1,085,253	$604,269
TOTALS		$8,027,650	$12,885,826			$17,541,301

TOTAL COST OF THE ALTERNATIVE: ***$17,541,301***

PRESENT WORTH CALCULATIONS

100-BC-5: REMOVAL, TREATMENT, AND DISPOSAL ALTERNATIVE WITH ION EXCHANGE

ANNUAL DISCOUNT RATE = 5%

YEAR	CAPITAL COST	O&M COST	DISCOUNT FACTOR	ANNUAL EXPENDITURE	PRESENT WORTH
0	$1,820,210	$0	1.0000	$1,820,210	$1,820,210
1	$0	$1,082,915	0.9524	$1,082,915	$1,031,368
2	$0	$1,007,655	0.9070	$1,007,655	$913,943
3	$0	$1,126,435	0.8638	$1,126,435	$973,015
4	$0	$1,007,655	0.8227	$1,007,655	$828,998
5	$0	$1,007,655	0.7835	$1,007,655	$789,498
6	$0	$1,126,435	0.7462	$1,126,435	$840,546
7	$0	$1,007,655	0.7107	$1,007,655	$716,140
8	$0	$1,007,655	0.6768	$1,007,655	$681,981
9	$0	$1,126,435	0.6446	$1,126,435	$726,100
10	$0	$1,007,655	0.6139	$1,007,655	$618,599
11	$0	$1,007,655	0.5847	$1,007,655	$589,176
12	$32,350	$1,007,655	0.5568	$1,040,005	$579,075
TOTALS	$1,852,560	$12,523,460			$11,108,649

TOTAL COST OF THE ALTERNATIVE: ***$11,108,649***

PRESENT WORTH CALCULATIONS

100-BC-5: REMOVAL, TREATMENT, AND DISPOSAL ALTERNATIVE WITH REVERSE OSMOSIS

ANNUAL DISCOUNT RATE = 5%

YEAR	CAPITAL COST	O&M COST	DISCOUNT FACTOR	ANNUAL EXPENDITURE	PRESENT WORTH
0	$4,912,670	$0	1.0000	$4,912,670	$4,912,670
1	$0	$2,145,518	0.9524	$2,145,518	$2,043,391
2	$0	$2,070,288	0.9070	$2,070,288	$1,877,751
3	$0	$2,188,928	0.8638	$2,188,928	$1,890,796
4	$0	$2,070,288	0.8227	$2,070,288	$1,703,226
5	$0	$2,070,288	0.7835	$2,070,288	$1,622,071
6	$0	$2,188,928	0.7462	$2,188,928	$1,633,378
7	$0	$2,070,288	0.7107	$2,070,288	$1,471,354
8	$0	$2,070,288	0.6768	$2,070,288	$1,401,171
9	$0	$2,188,928	0.6446	$2,188,928	$1,410,983
10	$0	$2,070,288	0.6139	$2,070,288	$1,270,950
11	$0	$2,070,288	0.5847	$2,070,288	$1,210,497
12	$32,320	$2,070,288	0.5568	$2,102,608	$1,170,732
OTALS	$4,944,990	$25,274,606			$23,618,970

TOTAL COST OF THE ALTERNATIVE: ***$23,618,970***

SECTION 1.2 COST MODEL ASSUMPTIONS

BC-5 AREA INSTITUTIONAL CONTROLS/CURRENT ACTION

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
ANA:02.08.02. Ground Water Analysis (Yrs 1-12)	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) • All on-site sample analyses performed by WHC mobile lab. • 10% off-site verification analysis of reduced analyte list with CLP protocol. (10% of 14 = 1 ea)	DOE Cost Meeting
WHC:02.08.02. Ground Water Analysis (Yrs 1-12)	• Assume sampling of 7 monitoring well on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total samples = 14 • 90% of samples for analysis at mobile lab (90% of 14 = 13)	DOE Cost Meeting
WHC:02.08.04. Ground Water Monitor Samples	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr) • Assume 2 field technicians for 6 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)	DOE Cost Meeting
WHC:13.21.11 Prepare Annual Report (Yrs 1-12)	• Assume 2 FTE's for 6 months each year	HR-3 Cost Workshop

BC-5 VERTICAL BARRIER (SLURRY WALL)

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
ANA:02.08.02. Ground Water Analysis Yr 1-12	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples) • Assume monthly performance monitoring of 7 wells for the 12-year lifecycle. (84 Samples) - Total samples = 98 • All on-site sample analyses performed by WHC mobile lab • 10% off-site verification analysis of reduced analyte list with CLP protocol. (10% of 98 = 10 ea)	Best professional judgement Best professional judgement DOE Cost Meeting DOE Cost Meeting
SUB:01.02.02 Mobilize Trailers	• Includes mobilization of field office, storage, and decontamination trailers	Best professional judgement
SUB:01.04.01 Setup Trailers	• Includes setup of field office, storage, and decontamination trailers	Best professional judgement
SUB:01.04.02. Construct Decon Area	• Construct decontamination area/pad for equipment and vehicles • Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 Backhoe, 1 pickup truck Output: Assumed duration for this activity is 3 crew days. • Allowance for Tank Assume 1000 gal plastic tank for water collection	Best professional judgement
SUB:01.04.03 Site Survey	• Survey site for construction	Best professional judgement
SUB:01.05 Construct Temporary Utilities	• Includes connections for temporary electricity, telephone, water, and sewer facilities	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:01.06 Pre-Construction Submittals	• Includes pre-construction submittals by fixed-price contractor	Best professional judgement
SUB:03.03 Earthwork	• Includes dirtwork to prepare site	Best professional judgement
SUB:03.04. Roads/Parking/ Curbs/Walks	• Access Roads to Wells Assume 750 lf of road per well, 10 ft wide, native materials 750 lf/well x 2 wells - 1,500 lf	Well spacing utilized to estimate road placement, Richardson Cost Estimating Guide
SUB:03.06. Electrical Distribution	• Includes pulling power to site	Best professional judgement
SUB:06.01.01. Groundwater Collection and Control	• Drill/Install Extr/Inject Wells Note: 2 new extraction wells and 2 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and packaging of contaminated well cuttings, transport to the disposal facility and associated disposal fees. • Allowance for well Head Covers Assume manhole type cover at each well head • Allowance for Well Pumps-100 gpm • Allowance for Controls and Connections at Well Heads • Allowance for Water Level Monitoring Instrumentation • Assume 5 piezometers per extraction well using well points • Allowance for well testing	Modelling, geological reports, and actual costs from the WHC RCRA drilling program Best professional judgement Richardson Cost Estimating Guide, Best professional judgement Best professional judgement Best professional judgement Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:06.01.04. Operations and Maintenance 3,6,9	• Allowance for Well Workover Assume 1 every 3 years for each well for the 12-year lifecycle. Workovers in years 3,6,9 • Allowance for Well Pump Assume 1 pump replacement per extraction well every three years for the 12-year lifecycle. Pump replacement in years 3,6,9.	Best professional judgement Best professional judgement
SUB:06.01.9X. Site Piping	• Allowance for Piping from extraction well to distribution point. Assume 750 lf of double-wall PVC piping per extraction well. 750 lf/well x 2 wells = 1500 lf • Allowance for leak detection • Allowance for Force Main Discharge Piping Assume 750 lf double-wall PVC piping per injection well. 750 lf/well x 2 wells = 1500 lf	Well spacing utilized to estimate flow line length, Best professional judgement
SUB:06:03. Slurry Walls	• Construct slurry wall: Assume 150 ft. deep x 9500 lf = 225,000 sf. • Install soil cap over barrier	Vendor quote
SUB:20.04 Site Restoration	• Includes revegetation at end of project	Best professional judgement
SUB:21.02.02 Demobilize Trailers	• Demobilize field office, storage, and decontamination trailers	Best professional judgement
SUB:21.04.02. Remove Decon Area	• Work to be performed: Remove decontamination area/pad for equipment and vehicles • Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup Output: Assumed duration for this activity is 1 crew day.	Best professional judgement
SUB:21.05 Disconnect Temporary Utilities	• Includes disconnecting electricity, telephone, water, and sewer services	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:21.06 Post-Construction Submittals	• Includes post-construction submittals by fixed-price contractor	Best professional judgement
WHC:02.08.02. Ground Water Analysis	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples) • Assume monthly performance monitoring of 7 wells for the 12-year lifecycle. (84 samples) - Total samples = 98 • 90% of samples analyzed by mobile lab (90% of 98 = 88) • All on-site samples analyses performed by WHC mobile lab	DOE Cost Meeting
WHC:02.08.04. Take Ground Water Samples	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples) • Assume 2 Field Technicians for 6 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)	DOE Cost Meeting Best Professional Judgement
WHC:06.03. Groundwater Collection and Control, Slurry Wall Yr. 1	• Assume WHC QA and safety oversite for the construction project.	Best professional judgement
WHC:06.05. Slurry Wall Operation and Maintenance	• Allowance for Electricity Wells: 720 kW-h/d Assume 24 hr/day x 365 days/yr Total = 262,800 kW-h/yr	Vendor catalogs, vendor quotes
WHC: 13.21.11. Prepare Annual Report (Yr 1)	• Assume 2 FTE's for 6 months per year	HR-3 Cost Workshop
WHC: 13.21.12 Prepare Annual Report (Yrs. 2-12)	• Assume 2 FTE's for 4 months per year	HR-3 Cost Workshop

BC-5 AREA ION EXCHANGE

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
ANA:02.08.02. Ground Water Analysis Yr - 1	• Assume shake-down period with following sampling of treatment system: - First 2 days: Sample every four hours of influent and effluent (24 samples) - Next 5 days: 1 sample per day of influent and effluent (10 samples) - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)	Best professional judgement
	• Minimum 1 sample per ion exchange media canister regeneration (60 days) of the influent and effluent for the 12-yr lifecycle (24 samples/yr)	Best professional judgement
	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total samples, Yr 1 = 86/yr	Best professional judgement
	• All on-site sample analyses performed by WHC mobile lab	DOE Cost Meeting
	• 10% off-site verification analysis of reduced analyte list with CLP protocol. - (10% of 86 = 9 ea)	DOE Cost Meeting

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
ANA:02.08.03. Ground Water Analysis Yrs 2-12	• Assume 1 sample per ion exchange media canister regeneration (60 days) of influent and effluent for the 12-yr lifecycle. (24 samples/yr) • Assume sampling of 7 monitoring wells on a semiannual basis for the 12-yr lifecycle (14 samples/yr) - Total samples, Yrs 2-12 = 38/yr • All on-site samples analyses performed by WHC mobile lab • 10% off-site verification analysis of reduced analyte list with CLP protocol (10% of 38 = 4 ea)	Best professional judgement Best professional judgement DOE Cost Meeting DOE Cost Meeting
SUB:01.02.02 Mobilize Trailers	• Includes mobilization of field office, storage, and decontamination trailers	Best professional judgement
SUB:01.04.01 Setup Trailers	• Includes setup of field office, storage, and decontamination trailers	Best professional judgement
SUB:01.04.02. Construct Decon Area	• Work to be Performed: Construct decontamination area/pad for equipment and vehicles. • Crew and Equipment Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck • Output: Assumed duration for this activity is 3 crew days • Allowance for Tank Assume 1000 gal plastic tank for water collection	Best professional judgement
SUB:01.04.03 Site Survey	• Survey site for construction	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:01.05 Construct Temporary Utilities	• Includes connections for temporary electricity, telephone, water, and sewer facilities	Best professional judgement
SUB:01.06 Pre-Construction Submittals	• Includes pre-construction submittals by fixed-price contractor	Best professional judgement
SUB:03.03 Earthwork	• Includes dirtwork to prepare site	Best professional judgement
SUB:03.04. Roads/Parking/Curbs/ Walks	• Access Roads to Wells Assume 750 lf of road per well, 10 ft wide, native materials 750 lf/well x 8 wells = 6,000 lf	Well spacing utilized to estimate road placement, Richardson Cost Estimating Guide
SUB:03.05. Fencing	• Allowance for Permanent Fencing Assume 7 ft high security fence	Industry standard, Best professional judgement
SUB:03.06 Electrical Distribution	• Includes pulling power to site	Best professional judgement
SUB:06. Groundwater Collection and Control	• Drill/install extraction wells Note: 4 new extraction and 4 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and packaging of contaminated well cuttings, transport to the disposal facility, and associated disposal fees. • Allowance for Well Pumps and Installation - 100 GPM • Allowance for Controls and Connections at Well Heads • Allowance for Water Level Monitoring Instrumentation • Assume 5 peizometers per extraction well using well points. • Allowance for Well Head Covers Assume manhole type cover at each well head • Allowance for Well Testing	Modelling and geological reports Richardson Cost Estimating Guide, Best professional judgement Best professional judgement Best professional judgement Best professional judgement Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:06.01.04. Operations and Maintenance 3, 6, 9	• Allowance for Well Workover Assume 1 workover every 3 yrs for each well for the 12-year lifecycle. Workovers in year 3,6,9 • Allowance for Well Pump Replacement Assume one pump replacement and installation per well every 3 years for the 12-year lifecycle Replacement in years 3,6,9	Best professional judgement Best professional judgement
SUB:06.01.9X. Site Piping	• Allowance for Piping from Well Head to Treatment Plant Assume 750 lf of double-wall PVC piping per extraction well 750 lf/well x 4 wells = 3,000 lf • Allowance for Leak Detection • Allowance for Force Main Discharge Piping Assume 750 lf single-wall PVC piping per injection well 750 lf/well x 4 wells = 3000 lf	Well spacing utilized to estimate flow line length, Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:12. Chemical Treatment	• Excavate and Install Building Foundation • Install Butler Building Assume a prefabricated heated building complete with frame, doors, roll up doors, gutters, insulation, and roof vent. • Ion Exchange Equipment/Staging Includes 1 x 400 gpm treatment system, resin regen equipment, 15 vessels. Resin included in O&M. • Allowance for Bldg Electrical Includes lighting, fixtures, motor starters, controllers, junction boxes, transformer, chart recorders, annunciators, panels, conduit, and wiring. • Allowance for Bldg Mechanical Includes equipment installation and connections, controls/instrumentation, interior piping (plastic), floor drains and piping, and HVAC.	Vendor quote Vendor quote, results from treatability study Best profession judgement Best professional judgement
SUB:20.04 Site Restoration	• Includes revegetation at end of project	Best professional judgement
SUB:21.02.02 Demobilize Trailers	• Demobilize field office, storage, and decontamination trailers	Best professional judgement
SUB:21.04. Demobilze Temp Facilities	• Includes demobilization of field office, storage, and decontamination trailers • Crew and Equipment: Fixed Price Contractor:1 Group 6 Operator, 3 Group 1 Laborer, and 3 Group 2 Laborers • Equipment: 1 backhoe, 1 pickup truck • Output: Assumed duration for this activity is 1 crew day	Best professional judgement
SUB:21.05 Disconnect Temporary Utilities	• Includes disconnecting electricity, telephone, water, and sewer services	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:21.06 Post-Construction Submittals	• Includes post-construction submittals by fixed-price contractor	Best professional judgement
WHC:02.08.02. Ground Water Analysis Yr - 1	• Assume shake-down period with following sampling of treatment system: - First 2 days: Sample every four hours of influent and effluent (24 samples) - Next 5 days: 1 sample per day of influent and effluent (10 samples) - Next 7 weeks: 1 sample per week of influent and effluent (14 samples/yr)	Best professional judgement, cost meeting
	• Minimum 1 sample per ion exchange media regeneration (60 days) of the influent and effluent for the 12-yr lifecycle (24 samples/yr).	DOE Cost Meeting
	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-yr lifecycle (14 samples/yr). - Total samples Yr 1 = 86	DOE Cost Meeting
	• 90% of samples analyzed a mobile lab (90% of 86 = 77)	DOE Cost Meeting
	• HACH kit samples are taken 1 per shift for the 12-yr lifecycle plus an additional 48 samples during the shake-down period. (Yr 1 = 1,143 samples)	DOE Cost Meeting

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
WHC:02.08.03. Ground Water Analysis Yr 2 - 12	• Assume 1 sample per ion exchange media canister regeneration (60 days) of the influent and effluent for the 12-yr lifecycle. (24 samples/yr)	Best professional judgement
	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr) - Total Samples Yrs 2-12 = 38	DOE Cost Meeting
	• 90% of samples analyzed at mobile lab (90% of 38 = 34)	DOE Cost Meeting
	• HACH kit samples are taken 1 per shift for the 12-yr lifecycle. (1,095 samples/year)	DOE Cost Meeting
WHC:02.08.04. Ground Water Monitor Samples	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr)	DOE Cost Meeting
	• Assume 2 field technicians for 6 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)	Best professional judgement
WHC:12.05.06 Personnel Training	• Includes operator time and allowance to attend 40-hour training • Allowance for maintenance manuals.	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
WHC:12.05.08 Operations & Maintenance Yrs 1-12	• Treatment facility will be fully staffed with 2 FTE's per shift, 3 shifts per day, 7 days per week. (365 days/yr x 24 hrs/day = 8760 hrs/yr)	Best professional judgement
	• Ion exchange media to be regenerated every 60 days for strontium 90 treatment	Vendor quote, treatability test report results
	• 2 FTE crew will be composed of the following members: 0.25 ea - supervisor 1.00 ea - operator 0.50 - TP tech support 0.25 ea - maintenance engineer	
	• Allowance for electricity Wells: 1450 kW-hr/d Assume 24 hrs/day x 365 days/yr Total = 529,000 kW-hr/yr	Vendor catalogs, vendor quotes
	• Allowance for Water Usage Water (6000 gallons) to flush flowlines.	Vendor quote
	• Ion Exchange Media Replacement Resin replacement once per year. 15 vessels x 45 cf/vessel x 6 changeouts = 4050 cf/yr	Vendor quote, best professional judgement
	• Disposal Fee for ion exchange media Assume disposal at ERDF for years 1-12 of the 12-year lifecycle	HR-3 Cost Workshop
WHC:12.05.11. Prepare Annual Report Yr 1	• Assume 2 FTE's for 6 months each year	HR-3 Cost Workshop
WHC:12.05.12. Prepare Annual Report Yrs 2-12	• Assume 2 FTE's for 4 months each year	HR-3 Cost Workshop

BC-5 AREA REVERSE OSMOSIS

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
ANA:02.08.02. Ground Water Analysis (YR 1)	• Assume shake-down period with the following sampling schedule for the treatment system: - First 2 days: Samples every four hours of influent and effluent (24 samples) - Next 5 days: 1 sample per day of influent and effluent (10 samples) - Next 7 weeks: 1 sample per week of influent and effluent (14 samples) • 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr) • Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total samples = 166 • All on-site samples analyses performed by WHC mobile lab • 10% off-site verification analysis of reduced analyte list with CLP protocol. (10% of 166 = 17 ea)	Best professional judgement Best professional judgement Best professional judgement DOE Cost Meeting DOE Cost Meeting
ANA:02.08.03. Ground Water Analysis (YRS 2-12)	• Assume 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle. (104 samples/yr) • Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total Samples = 118 • All on-site sample analyses performed by WHC mobile lab • 10% off-site verification analysis of reduced analyte list with CLP protocol (10% of 118 = 12)	Best professional judgement Best professional judgement DOE Cost Meeting DOE Cost Meeting
SUB:01.02.02 Mobilize Trailers	• Includes mobilization of field office, storage, and decon trailers	Best professional judgement
SUB:01.04.01. Setup/Construct Temporary Facilities	• Includes setup of field office, storage, and decon trailers	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:01.04.02. Construct Decon Area	• Work to be performed: Construct decontamination area/pad for equipment and vehicles. • Crew and Equipment • Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Assumed duration for this activity is 3 crew days. • Allowance for Tank Assume 1000 gal plastic tank for water collection	Best professional judgement
SUB:01.04.03. Site Survey	• Survey site for construction	Best professional judgement
SUB:01.05. Construct Temporary Utilities	• Includes connections for temporary electricity, telephone, water, and sewer services	Best professional judgement
SUB:01.06. Pre-Construction Submittals	• Includes pre-construction submittals by fixed-price contractor	Best professional judgement
SUB:03.03. Earthwork	• Includes dirtwork to prepare site	Best professional judgement
SUB:03.04. Roads/Parking/ Curbs/Walks	• Assume 750 lf of access road per well. 10 ft wide, native materials 1500 lf/well x 8 wells = 6,000 lf	Well spacing utilized to estimate road placement, Richardson Cost Estimating Guide
SUB:03.05. Fencing	• Allowance for Permanent Fencing Assume 7 ft high security fence	Industry standard, Best professional judgement
SUB:03.06 Electrical Distribution	• Includes pulling power to site	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:06. Groundwater Collection & Control	• Drill/Install Extr/Inject Wells Note: 4 new extraction wells and 4 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and cuttings, transport to the disposal facility, and associated disposal fees. • Allowance for Well Pumps - 100 gpm • Allowance for Controls and Connections at Well Heads • Allowance for Water Level Monitoring Instrumentation Assume 5 peizometers per extraction well using well points • Allowance for Well Head Covers Assume manhole type cover at each well head • Allowance for Well Testing	Modelling, geological reports, and actual costs form WHC RCRA Drilling Program Richardson Cost Estimating Guide, Best professional judgement Best professional judgement Best professional judgement Best professional judgement
SUB:06.01.04 Operations and Maintenance 3,6,9	• Allowance for Well Workover Assume 1 workover for every 3 yrs. for each well; workovers in years 3,6,9 • Allowance for Well Pump Replacement. Assume 1 pump replacement per extraction well every 3 years; pump replacements in years 3,6,9	Best professional judgement Best professional judgement
SUB:06.01.9X. Site Piping	• Allowance for Piping from Well Head to Treatment Plant Assume 750 lf of double-wall PVC piping per extraction well. 750 lf/well x 4 wells = 3,000 lf • Allowance for Force Main Discharge Piping Assume 750 lf of single-wall PVC for each injection well. 750 lf/well x 4 wells - 3,000 lf	Well spacing utilized to estimate flow line length, Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB:13.21.04. Construction of Permanent Plant	• Excavate and Install Building Foundation • Install Butler Building Assume a prefabricated heated building complete with frame, doors, roll up doors, gutters, insulation, and roof vent. • Reverse Osmosis Equipment/Staging Includes 1 - 400 gpm treatment system, 225 psi inlet pressure, 10% reject • Vapor Recompression Evaporator Capacity = 400 gpm x 0.1 = 40 gpm, includes startup boiler, 2% reject • Rotary Drum Filter/Dryer Liquid loading: 400 gpm x 0.1 x 0.02 = 0.8 gpm = 400 lbs/hr Drying area = 70 sf • Steam Generator Evaporate 0.8 gpm = 400 lbs/hr 685,000 BTU • Allowance for Bldg Electrical Includes lighting, fixtures, motor starters, controllers, junction boxes, transformer, chart recorders, annunciators, panels, conduit, and wiring. • Allowance for Bldg Mechanical Includes equipment installation and connections, controls/instrumentation, interior piping (plastic), floor drains and piping, and HVAC.	Best professional judgement Vendor quote Vendor quote Richardson Cost Estimating Guide Vendor catalog Best professional judgement Best professional judgement
SUB: 20.04 Site Restoration	• Includes revegetation at end of project	Best professional judgement
SUB: 21.02.02 Demobilization	• Demobilize field office, storage, and decontamination trailers	Best professional judgement
SUB: 21.04.02. Remove Decon Area-Yr 12	• Includes removal of decontamination area • Crew and Equipment: Fixed Price Contractor:1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup Output: Assumed duration for this activity is 1 crew day	Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
SUB 21.05 Disconnect Temporary Utilities	• Includes disconnecting electricity, telephone, water, and sewer services.	Best professional judgement
SUB 21.06 Post-Construction Submittals	• Includes post-construction submittals by fixed-price contractor	Best professional judgement
WHC:02.08.02. Ground Water Analysis-Yr 1	• Assume shake-down period with the following sampling of treatment system: - First 2 days: Sample every four hours of influent and effluent (24 samples) - Next 5 days: 1 sample per day of influent and effluent (10 samples) - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)	Best professional judgement, cost meeting
	• 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr)	Best professional judgement
	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total samples = 166	Best professional judgement
	• 90% of samples for analysis at mobile lab (90% of 166 = 149)	
	• HACH kit samples are taken 1 per shift for the 12-yr lifecycle plus an additional 48 samples during the shake-down period. (1143 samples)	DOE cost meeting
	• HACH Kit Replacement Assume 1 per yr	DOE cost meeting

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
WHC:02.08.03. Ground Water Analysis-Yrs 2-12	• 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr) • Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr) - Total samples = 118 • 90% of samples for analysis at mobile lab (90% of 118 = 106) • HACH kit samples are taken 1 per shift for the 12-yr lifecycle (1143 samples) • WHC HACH kit Replacement Assume 1 per yr	Best professional judgement DOE cost meeting DOE cost meeting DOE cost meeting
WHC:02.08.04. Ground Water Monitor Samples	• Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr) • Assume 2 field technicians for 6 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)	DOE cost meeting Best professional judgement
WHC:13.21.06. Personnel Training	• Note: This account to allow for operator time and an allowance for 40 hour training course	Best professional judgement
WHC:13.21.08. Operation and Maint-Yrs 1-12	• Treatment facility will be fully staffed with 2 FTE's per shift, 3 shifts per day, 7 days per week. (365 days/year x 24 hrs/day = 8760 hrs) • Reverse Osmosis filters will be replaced every week for the 12-year lifecycle. • 2 FTE crew will be composed of the following members: 0.25 ea - supervisor 1.00 ea - operator 0.50 ea - TP tech support 0.25 ea - maintenance supervisor	Best professional judgement Best professional judgement

TASK NUMBER	ASSUMPTIONS	JUSTIFICATION
WHC:13.21.08. Operation and Maint-Yrs 1-12 (Continued)	• Allowance for Electricity Wells: 1450 kW-hr/d RO System: 1567 kW-hr/d Recompr Evap: 4608 kW-hr/d Rotary Filter/Drum: 4816 kW-hr/d Assume 24 hrs/day x 365 days/yr Total = 4,540,965 kW-hr/yr	Vendor catalogs, vendor quotes
	• RO System Chemicals Includes scale inhibitors, $0.34/1000 gal 400 gpm x 1440 m/d x 365 d/y = 210.2 MMgpy	Vendor quote
	• Reverse Osmosis Filter Replacement Assume replacement of 2 filters on a weekly basis for the 12-year lifecycle. (52 wk/yr x 2 filters/wk)	Best professional judgement
	• Disposal Fee for Reverse Osmosis Filters Assume disposal at ERDF for years 1 - 12 of the 12-year lifecycle. Assume each filter to be 40 cu ft.	HR-3 cost workshop
	• Disposal Fee - Evaporation Cake 400 gpm x 325 ppm = 16.6 cf/day 16.6 cf/day x 365 days = 6055 cf/year	Best professional judgement
	Assume 50% volume increase to stabilize evaporation cake 1.5 x 6055 cf/yr = 9,083 cf/yr	HR-3 Cost Workshop
	• Allowance for Water Usage. Assume 1000 gal per month usage for the 12 year lifecycle	Best professional judgement
WHC:13.21.11. Prepare Annual Report (Yr-1)	• Assume 2 FTE's for 6 months each year	HR-3 Cost Workshop
WHC:13.21.12. Prepare Annual Report (Yrs 2-12)	• Assume 2 FTE's for 4 months each year	HR-3 Cost Workshop

SECTION 1.3 COST SUMMARY TABLES

Cost Summary for 100 BC-5 Area			Cost[b]						
Cost Element			Type		Year(s) Applicable	Institutional Controls/ Continued Current Actions	Slurry Wall	Pump and Treat with Ion Exchange	Pump and Treat with Reverse Osmosis
			CAP	O&M					
ANA: Off-Site Analytical Services									
ANA:02	Monitoring, Sampling, and Analysis	Offsite Yr 1		x	1	4,210	42,100	37,890	71,570
		Offsite Yrs 2-12		x	2-12	4,210	42,100	16,840	50,520
SUB: Fixed Price Contractor									
SUB:01	Mobilization & Preparatory		x		0	-	37,820	37,990	37,950
SUB:03	Site Work		x		0	-	28,510	54,700	54,640
SUB:06	Groundwater Collection and Control	Drilling	x		0	-	616,960	1,291,120	1,289,620
		O&M 3,6,9		x	3,6,9	-	59,130	118,780	118,640
		Piping	x		0	-	75,830	134,280	134,120
		Slurry Wall	x		0	-	7,239,670	-	-
SUB:12	Chemical Treatment		x		0	-	-	302,120	-
SUB:13	Physical Treatment		x		0	-	-	-	3,396,340
SUB:20	Site Restoration		x		12	-	9,510	12,910	12,900
SUB:21	Demobilization		x		12	-	19,350	19,440	19,420
WHC:Westinghouse Hanford Company									
WHC:02	Monitoring, Sampling, & Analysis	Yr 1		x	1	5860	35,200	31,610	60,410
		Yrs 2-12		x	2-12	5860	35,860	14,380	43,210
		Yrs 1-12		x	1-12	-	660	660	660

Cost Summary for 100 BC-5 Area			Cost [b]						
Cost Element			Type		Year(s) Applicable	Institutional Controls/ Continued Current Actions	Slurry Wall	Pump and Treat with Ion Exchange	Pump and Treat with Reverse Osmosis
			CAP	O&M					
WHC:06	Groundwater Collection and Control	Yr 1		x	1	-	2,300	-	-
		Yrs 2-12		x	2-12	-	-	-	-
WHC:12	Chemical Treatment	Training Yr 1		x	1	-	-	6900	-
		O&M Yrs 1-12		x	1-12	-	-	631,250	-
		Annual Rpt Yr 1		x	1	-	-	90,150	-
		Annual Rpt Yrs 2-12		x	2-12	-	-	60,070	-
WHC:13	Physical Treatment [a]	Training Yr 1		x	1	-	-	-	6900
		O&M Yrs 1-12		x	1-12	-	15,770	-	1,234,500
		Annual Rpt Yr 1		x	1	90,150	90,150	-	90,150
		Annual Rpt Yrs 2-12		x	2-12	60,070	60,070	-	60,070
Miscellaneous	Overhead			x	1-12	-	99,617	24,175	62,169
	Profit			x	1-12	-	43,362	10,977	28,229
	Bond			x	1-12	-	3,472	1,120	2,392
	B&O Tax			x	1-12	-	3,152	768	1,974
	Material/Supply MPR			x	1-12	-	-	659	4572
	Subcontractor MPR			x	1-12	-	49,195	11,993	30,803

Cost Summary for 100 BC-5 Area		Cost [b]						
Cost Element		Type: CAP	Type: O&M	Year(s) Applicable	Institutional Controls/ Continued Current Actions	Slurry Wall	Pump and Treat with Ion Exchange	Pump and Treat with Reverse Osmosis
Project Management/Construction Management			x	1-12	1,951	111,016	36,878	86,614
General & Admin/Common Support Pool			x	1-12	3,814	217,036	72,098	169,332
Contingency			x	1-12	6,693	375,083	125,787	295,243
Total Miscellaneous				1-12	12,458	901,933	284,455	681,328
SUMMARY								
Capital	Year 0				0	7,998,790	1,820,210	4,912,670
	Year 12				0	28,860	32,350	32,320
Annual O&M	Year 1				112,678	1,088,113	1,082,915	2,145,518
	Years 2,4,5,7 8,10,11,12,				82,598	1,056,393	1,007,655	2,070,288
	Years 3,6,9				82,598	1,115,523	1,126,435	2,188,928
Present Worth					760,723	17,541,301	11,108,649	23,618,970

(a) For Institutional Controls/Continued Current Actions and Slurry Wall = Annual Report

(b) Costs for task/subtask/sub-subtask elements are obtained from the Contract Cost column of the level 5 Project Owner Summaries (MCACES Cost Model Runs-Section 1.4). Yearly Miscellaneous Costs are obtained by taking 1/12 of the individual line-item Miscellaneous Costs from the Total Cost Column of the Level 1 Project Direct Summaries (12 years is the project duration).

CAP = Capital

O&M = Operation & Maintenance

SECTION 1.4 REMEDIAL ALTERNATIVE COST MODELS

HANFORD: ER PROGRAM
100 BC-5 INSTIT CONTROLS/CONT'D
CURRENT ACTIONS
1.4.10.1.1.10.5.2.4
PRELIMINARY COST MODEL

Designed By:
Estimated By: IT Corporation

Prepared By: USACE/CENPW COST ENG BRANCH
Project Time & Cost, Inc.

Date: 10/07/94

M C A C E S G O L D E D I T I O N

Release 5.20J

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

*** END TABLE OF CONTENTS ***

Fri 07 Oct 1994 U.S. Army Corps of Engineers TIME 07:10:44

PROJECT BNOACT: HANFORD: ER PROGRAM - 100 BC-5 INSTIT CONTROLS/CONT'D

100 BC-5 INSTIT CONTROLS/CONT'D CURRENT ACTIONS SUMMARY PAGE 1

** PROJECT OWNER SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		4,210	0	0	0	1,470	5,680	
WHC	Westinghouse Hanford Company		156,080	0	23,410	45,770	78,840	304,110	
	HANFORD: ER PROGRAM		160,290	0	23,410	45,770	80,320	309,790	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis		4,210	0	0	0	1,470	5,680	
Off-Site Analytical Services		4,210	0	0	0	1,470	5,680	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis		5,860	0	880	1,720	2,960	11,420	
WHC:13 Annual Report		150,220	0	22,530	44,050	75,880	292,680	
Westinghouse Hanford Company		156,080	0	23,410	45,770	78,840	304,110	
HANFORD: ER PROGRAM		160,290	0	23,410	45,770	80,320	309,790	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis								
ANA:02.08 Sampling Rad Contaminated Media								
ANA:02.08.02 Ground Water Analysis (Yrs 1-12)	1.00 EA	4,210	0	0	0	1,470	5,680	5683.50
Sampling Rad Contaminated Media		4,210	0	0	0	1,470	5,680	
Monitoring, Sampling & Analysis		4,210	0	0	0	1,470	5,680	
Off-Site Analytical Services		4,210	0	0	0	1,470	5,680	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis								
WHC:02.08 Sampling Rad Contaminated Media								
WHC:02.08.02 Ground Water Analysis-Yrs (1-12)	13.00 EA	5,200	0	780	1,520	2,630	10,130	779.36
WHC:02.08.04 Ground Water Monitor Samples	24.00 HR	660	0	100	190	330	1,290	53.82
Sampling Rad Contaminated Media		5,860	0	880	1,720	2,960	11,420	
Monitoring, Sampling & Analysis		5,860	0	880	1,720	2,960	11,420	
WHC:13 Annual Report								
WHC:13.21 Annual Report								
WHC:13.21.11 Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	13,520	26,440	45,540	175,640	84.44
WHC:13.21.12 Prepare Annual Report (Yrs 2-12)		60,070	0	9,010	17,620	30,340	117,040	
Annual Report		150,220	0	22,530	44,050	75,880	292,680	
Annual Report		150,220	0	22,530	44,050	75,880	292,680	
Westinghouse Hanford Company		156,080	0	23,410	45,770	78,840	304,110	
HANFORD: ER PROGRAM		160,290	0	23,410	45,770	80,320	309,790	

** PROJECT INDIRECT SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		4,210	0	0	0	0	0	4,210	
WHC	Westinghouse Hanford Company		156,080	0	0	0	0	0	156,080	
	HANFORD: ER PROGRAM		160,290	0	0	0	0	0	160,290	
	Project Management/Construction Mgnt								23,410	
	SUBTOTAL								183,700	
	General & Admin/Common Support Pool								45,770	
	SUBTOTAL								229,470	
	Contingency								80,320	
	TOTAL INCL OWNER COSTS								309,790	

** PROJECT INDIRECT SUMMARY - LEVEL 2 (Rounded to 10's) **

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis		4,210	0	0	0	0	0	4,210	
Off-Site Analytical Services		4,210	0	0	0	0	0	4,210	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis		5,860	0	0	0	0	0	5,860	
WHC:13 Annual Report		150,220	0	0	0	0	0	150,220	
Westinghouse Hanford Company		156,080	0	0	0	0	0	156,080	
HANFORD: ER PROGRAM		160,290	0	0	0	0	0	160,290	
Project Management/Construction Mgnt								23,410	
SUBTOTAL								183,700	
General & Admin/Common Support Pool								45,770	
SUBTOTAL								229,470	
Contingency								80,320	
TOTAL INCL OWNER COSTS								309,790	

** PROJECT INDIRECT SUMMARY - LEVEL 4 (Rounded to 10's) **

		QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services									
ANA:02	Monitoring, Sampling & Analysis									
ANA:02.08	Sampling Rad Contaminated Media									
ANA:02.08.02	Ground Water Analysis (Yrs 1-1	1.00 EA	4,210	0	0	0	0	0	4,210	4210.00
	Sampling Rad Contaminated Medi		4,210	0	0	0	0	0	4,210	
	Monitoring, Sampling & Analysi		4,210	0	0	0	0	0	4,210	
	Off-Site Analytical Services		4,210	0	0	0	0	0	4,210	
WHC	Westinghouse Hanford Company									
WHC:02	Monitoring, Sampling & Analysis									
WHC:02.08	Sampling Rad Contaminated Media									
WHC:02.08.02	Ground Water Analysis-Yrs (1-1	13.00 EA	5,200	0	0	0	0	0	5,200	400.00
WHC:02.08.04	Ground Water Monitor Samples	24.00 HR	660	0	0	0	0	0	660	27.62
	Sampling Rad Contaminated Medi		5,860	0	0	0	0	0	5,860	
	Monitoring, Sampling & Analysi		5,860	0	0	0	0	0	5,860	
WHC:13	Annual Report									
WHC:13.21	Annual Report									
WHC:13.21.11	Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	0	0	0	0	90,150	43.34
WHC:13.21.12	Prepare Annual Report (Yrs 2-1		60,070	0	0	0	0	0	60,070	
	Annual Report		150,220	0	0	0	0	0	150,220	
	Annual Report		150,220	0	0	0	0	0	150,220	
	Westinghouse Hanford Company		156,080	0	0	0	0	0	156,080	
	HANFORD: ER PROGRAM		160,290	0	0	0	0	0	160,290	
	Project Management/Construction Mgnt								23,410	
	SUBTOTAL								183,700	
	General & Admin/Common Support Pool								45,770	
	SUBTOTAL								229,470	
	Contingency								80,320	

** PROJECT INDIRECT SUMMARY - LEVEL 4 (Rounded to 10's) **

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
TOTAL INCL OWNER COSTS								309,790	

		QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		0	0	0	4,210	4,210	
WHC	Westinghouse Hanford Company		150,880	0	0	5,200	156,080	
	HANFORD: ER PROGRAM		150,880	0	0	9,410	160,290	
	Project Management/Construction Mgnt						23,410	
	SUBTOTAL						183,700	
	General & Admin/Common Support Pool						45,770	
	SUBTOTAL						229,470	
	Contingency						80,320	
	TOTAL INCL OWNER COSTS						309,790	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis		0	0	0	4,210	4,210	
Off-Site Analytical Services		0	0	0	4,210	4,210	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis		660	0	0	5,200	5,860	
WHC:13 Annual Report		150,220	0	0	0	150,220	
Westinghouse Hanford Company		150,880	0	0	5,200	156,080	
HANFORD: ER PROGRAM		150,880	0	0	9,410	160,290	
Project Management/Construction Mgnt						23,410	
SUBTOTAL						183,700	
General & Admin/Common Support Pool						45,770	
SUBTOTAL						229,470	
Contingency						80,320	
TOTAL INCL OWNER COSTS						309,790	

		QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services							
ANA:02	Monitoring, Sampling & Analysis							
ANA:02.08	Sampling Rad Contaminated Media							
ANA:02.08.02	Ground Water Analysis (Yrs 1-12)	1.00 EA	0	0	0	4,210	4,210	4210.00
	Sampling Rad Contaminated Media		0	0	0	4,210	4,210	
	Monitoring, Sampling & Analysis		0	0	0	4,210	4,210	
	Off-Site Analytical Services		0	0	0	4,210	4,210	
WHC	Westinghouse Hanford Company							
WHC:02	Monitoring, Sampling & Analysis							
WHC:02.08	Sampling Rad Contaminated Media							
WHC:02.08.02	Ground Water Analysis-Yrs (1-12)	13.00 EA	0	0	0	5,200	5,200	400.00
WHC:02.08.04	Ground Water Monitor Samples	24.00 HR	660	0	0	0	660	27.62
	Sampling Rad Contaminated Media		660	0	0	5,200	5,860	
	Monitoring, Sampling & Analysis		660	0	0	5,200	5,860	
WHC:13	Annual Report							
WHC:13.21	Annual Report							
WHC:13.21.11	Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	0	0	90,150	43.34
WHC:13.21.12	Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
	Annual Report		150,220	0	0	0	150,220	
	Annual Report		150,220	0	0	0	150,220	
	Westinghouse Hanford Company		150,880	0	0	5,200	156,080	
	HANFORD: ER PROGRAM		150,880	0	0	9,410	160,290	
	Project Management/Construction Mgnt						23,410	
	SUBTOTAL						183,700	
	General & Admin/Common Support Pool						45,770	
	SUBTOTAL						229,470	
	Contingency						80,320	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
TOTAL INCL OWNER COSTS						309,790	

ANA:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA. Off-Site Analytical Services
ANA:02. Monitoring, Sampling & Analysis
ANA:02.08. Sampling Rad Contaminated Media
ANA:02.08.02. Ground Water Analysis (Yrs 1-12)
Assumptions:

1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle
(14 samples/yr)

   - Total samples = 14

2. All on-site sample analyses performed by WHC mobile lab.

3. 10% off-site verification analysis of reduced analyte list with CLP protocol.
(10% of 14 = 1 ea)

ANA	Analyze LLW Sample - Off-site Lab	1.00 EA	0.00 0	0.00 0	0.00 0	4210.00 4,210	4210.00 4,210	4210.00
	Ground Water Analysis (Yrs 1-12)	1.00 EA	0	0	0	4,210	4,210	4210.00
	Sampling Rad Contaminated Media		0	0	0	4,210	4,210	
	Monitoring, Sampling & Analysis		0	0	0	4,210	4,210	
	Off-Site Analytical Services		0	0	0	4,210	4,210	

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC. Westinghouse Hanford Company
WHC:02. Monitoring, Sampling & Analysis
WHC:02.08. Sampling Rad Contaminated Media
WHC:02.08.02. Ground Water Analysis-Yrs (1-12)
Assumptions:

1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total samples = 14

2. 90% of samples for analysis at mobile lab (90% of 14 = 13)

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
		13.00 EA	0	0	0	5,200	5,200	400.00
	Ground Water Analysis-Yrs (1-12)	13.00 EA	0	0	0	5,200	5,200	400.00

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:02.08.04. Ground Water Monitor Samples Work to be Performed: Take semiannual groundwater monitoring samples. Assumptions: 1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr) 2. Assume 2 field Technicians for 6 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)								
WHC Technician, Environmental Restoration Ops - 2 ea	24.00 HR	85201	27.62 663	0.00 0	0.00 0	0.00 0	27.62 663	27.62
Ground Water Monitor Samples	24.00 HR		663	0	0	0	663	27.62
Sampling Rad Contaminated Media			663	0	0	5,200	5,863	
Monitoring, Sampling & Analysis			663	0	0	5,200	5,863	

WHC:13. Annual Report		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13. Annual Report									
WHC:13.21. Annual Report									
WHC:13.21.11. Prepare Annual Report (Yr 1) Assume 2 FTE's for 6 months each year.									
WHC	Engineer, Environmental Restoration Ops - 1 ea	1040.00 HR	85101	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
WHC	Scientist, Environmental Restoration Ops - 1 ea	1040.00 HR	85102	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
	Prepare Annual Report (Yr 1)	2080.00 HR		90,148	0	0	0	90,148	43.34

WHC:13. Annual Report		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13.21.12. Prepare Annual Report (Yrs 2-12) Assume a 66% effort level of the Year 1 Report (FTE's for 4 months each year)									
WHC	Engineer, Environmental Restoration Ops	693.00 HR	85101	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
WHC	Scientist, Environmental Restoration Ops	693.00 HR	85102	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
	Prepare Annual Report (Yrs 2-12)			60,070	0	0	0	60,070	
	Annual Report			150,218	0	0	0	150,218	
	Annual Report			150,218	0	0	0	150,218	
	Westinghouse Hanford Company			150,881	0	0	5,200	156,081	
	HANFORD: ER PROGRAM			150,881	0	0	9,410	160,291	

** LABOR BACKUP **

SRC LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
WHC 85101	Engineer, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85102	Scientist, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85201	Technician, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	24

HANFORD: ER PROGRAM
100 BC-5 SLURRY WALL
1.4.10.1.1.10.5.2.4
VERTICAL BARRIER
PRELIMINARY COST MODEL

Designed By:
Estimated By: IT Corporation

Prepared By: USACE/CENPW COST ENG BRANCH
Project Time & Cost, Inc.

Date: 10/07/94

M C A C E S G O L D E D I T I O N
Composer GOLD Copyright (C) 1985, 1988, 1990, 1992
by Building Systems Design, Inc.
Release 5.20J

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

Fri 07 Oct 1994

U.S. Army Corps of Engineers
PROJECT BSLRRY: HANFORD: ER PROGRAM - 100 BC-5 SLURRY WALL
VERTICAL BARRIER MODEL
** PROJECT OWNER SUMMARY - LEVEL 1 (Rounded to 10's) **

TIME 07:12:44
SUMMARY PAGE 1

		QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		42,100	0	0	0	14,740	56,840	
SUB	Fixed Price Contractor		8,086,790	590,340	1,301,570	2,544,570	4,383,140	16,906,390	
WHC	Westinghouse Hanford Company		204,150	0	30,620	59,870	103,130	397,770	
	HANFORD: ER PROGRAM		8,333,040	590,340	1,332,190	2,604,430	4,501,000	17,361,000	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis		42,100	0	0	0	14,740	56,840	
Off-Site Analytical Services		42,100	0	0	0	14,740	56,840	
SUB Fixed Price Contractor								
SUB:01 Mobilization & Preparatory Work		37,820	2,760	6,090	11,900	20,500	79,070	
SUB:03 Site Work		28,510	2,080	4,590	8,970	15,450	59,600	
SUB:06 Groundwater Collection & Control		7,991,590	583,390	1,286,250	2,514,610	4,331,540	16,707,380	
SUB:20 Site Restoration		9,510	690	1,530	2,990	5,160	19,880	
SUB:21 Demobilization		19,350	1,410	3,110	6,090	10,490	40,460	
Fixed Price Contractor		8,086,790	590,340	1,301,570	2,544,570	4,383,140	16,906,390	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis		35,860	0	5,380	10,520	18,120	69,870	
WHC:06 Groundwater Collection & Control		2,300	0	350	680	1,160	4,490	
WHC:13 Slurry Wall		165,990	0	24,900	48,680	83,850	323,410	
Westinghouse Hanford Company		204,150	0	30,620	59,870	103,130	397,770	
HANFORD: ER PROGRAM		8,333,040	590,340	1,332,190	2,604,430	4,501,000	17,361,000	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis								
ANA:02.08 Sampling Rad Contaminated Media								
ANA:02.08.02 Ground Water Analysis Yr 1 - 12								
Ground Water Analysis Yr 1 - 12	10.00 EA	42,100	0	0	0	14,740	56,840	5683.50
Sampling Rad Contaminated Media		42,100	0	0	0	14,740	56,840	
Monitoring, Sampling & Analysis		42,100	0	0	0	14,740	56,840	
Off-Site Analytical Services		42,100	0	0	0	14,740	56,840	
SUB Fixed Price Contractor								
SUB:01 Mobilization & Preparatory Work								
SUB:01.02 Mobilize Personnel & Equipment								
SUB:01.02.02 Mobilize Trailers								
Mobilize Trailers		960	70	160	300	520	2,020	
Mobilize Personnel & Equipment		960	70	160	300	520	2,020	
SUB:01.04 Setup/Construct Temp Facilities								
SUB:01.04.01 Establish Facilities								
SUB:01.04.01.02 Setup Trailers		4,900	360	790	1,540	2,650	10,230	
Establish Facilities		4,900	360	790	1,540	2,650	10,230	
SUB:01.04.02 Construct Decon Area								
Construct Decon Area	24.00 HR	11,810	860	1,900	3,720	6,400	24,700	1029.00
SUB:01.04.03 Site Survey								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Site Survey		1,290	90	210	400	700	2,690	
Setup/Construct Temp Facilities		17,990	1,310	2,900	5,660	9,750	37,620	
SUB:01.05 Construct Temporary Utilities								
Construct Temporary Utilities		6,010	440	970	1,890	3,260	12,560	
SUB:01.06 Pre-Construction Submittals								
Pre-Construction Submittals	4.00 EA	12,850	940	2,070	4,040	6,970	26,870	6717.89
Mobilization & Preparatory Work		37,820	2,760	6,090	11,900	20,500	79,070	
SUB:03 Site Work								
SUB:03.03 Earthwork								
Earthwork		6,430	470	1,030	2,020	3,480	13,440	
SUB:03.04 Roads/Parking/Curbs/Walks								
Roads/Parking/Curbs/Walks		9,230	670	1,490	2,900	5,000	19,290	
SUB:03.06 Electrical Distribution								
Electrical Distribution		12,850	940	2,070	4,040	6,970	26,870	
Site Work		28,510	2,080	4,590	8,970	15,450	59,600	
SUB:06 Groundwater Collection & Control								
SUB:06.01 Extraction & Injection Wells								
SUB:06.01.01 Well Drilling & Construction								
Well Drilling & Construction	4.00 EA	616,960	45,040	99,300	194,130	334,400	1,289,830	322458.55
SUB:06.01.04 Operations and Maintenance 3,6,9								
Operations and Maintenance 3,6,9		59,130	4,320	9,520	18,600	32,050	123,610	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
SUB:06.01.9X Site Piping								
Site Piping		75,830	5,540	12,210	23,860	41,100	158,540	
Extraction & Injection Wells		751,920	54,890	121,020	236,600	407,550	1,571,990	
SUB:06.03 Slurry Walls								
Slurry Walls		7,239,670	528,500	1,165,220	2,278,010	3,923,990	15,135,400	
Groundwater Collection & Control		7,991,590	583,390	1,286,250	2,514,610	4,331,540	16,707,380	
SUB:20 Site Restoration								
SUB:20.04 Revegetation and Planting								
Revegetation and Planting		9,510	690	1,530	2,990	5,160	19,880	
Site Restoration		9,510	690	1,530	2,990	5,160	19,880	
SUB:21 Demobilization								
SUB:21.02 Demobilize Personnel & Equipment								
SUB:21.02.02 Demobilize Trailers								
Demobilize Trailers		960	70	160	300	520	2,020	
Demobilize Personnel & Equipment		960	70	160	300	520	2,020	
SUB:21.04 Demobilize Temp Facilities								
SUB:21.04.02 Remove Decon Area								
Remove Decon Area	8.00 HR	2,320	170	370	730	1,260	4,850	606.56
Demobilize Temp Facilities		2,320	170	370	730	1,260	4,850	
SUB:21.05 Disconnect Temporary Utilities								
Disconnect Temporary Utilities		3,210	230	520	1,010	1,740	6,720	
SUB:21.06 Post-Construction Submittals								

	QUANTITY	UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Post-Construction Submittals	4.00	EA	12,850	940	2,070	4,040	6,970	26,870	6717.89
Demobilization			19,350	1,410	3,110	6,090	10,490	40,460	
Fixed Price Contractor			8,086,790	590,340	1,301,570	2,544,570	4,383,140	16,906,390	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis									
WHC:02.08 Sampling Rad Contmntd Media 1-12									
WHC:02.08.02 Ground Water Analysis									
Ground Water Analysis	88.00	EA	35,200	0	5,280	10,320	17,780	68,580	779.35
WHC:02.08.04 Take Ground Water Samples									
Take Ground Water Samples	24.00	HR	660	0	100	190	330	1,290	53.82
Sampling Rad Contmntd Media 1-12			35,860	0	5,380	10,520	18,120	69,870	
Monitoring, Sampling & Analysis			35,860	0	5,380	10,520	18,120	69,870	
WHC:06 Groundwater Collection & Control									
WHC:06.03 Slurry Walls 1 - 12									
Slurry Walls 1 - 12			2,300	0	350	680	1,160	4,490	
Groundwater Collection & Control			2,300	0	350	680	1,160	4,490	
WHC:13 Slurry Wall									
WHC:13.21 Slurry Wall									
WHC:13.21.08 Operation and Maint-Yrs 1-12									
Operation and Maint-Yrs 1-12			15,770	0	2,370	4,620	7,970	30,720	
WHC:13.21.11 Prepare Annual Report									

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Prepare Annual Report		90,150	0	13,520	26,440	45,540	175,640	
WHC:13.21.12 Prepare Annual Report (Yrs 2-12)								
Prepare Annual Report (Yrs 2-12)		60,070	0	9,010	17,620	30,340	117,040	
Slurry Wall		165,990	0	24,900	48,680	83,850	323,410	
Slurry Wall		165,990	0	24,900	48,680	83,850	323,410	
Westinghouse Hanford Company		204,150	0	30,620	59,870	103,130	397,770	
HANFORD: ER PROGRAM		8,333,040	590,340	1,332,190	2,604,430	4,501,000	17,361,000	

** PROJECT INDIRECT SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		42,100	0	0	0	0	0	42,100	
SUB	Fixed Price Contractor		6,291,560	1,195,400	520,340	41,660	37,830	0	8,086,790	
WHC	Westinghouse Hanford Company		204,150	0	0	0	0	0	204,150	
	HANFORD: ER PROGRAM		6,537,810	1,195,400	520,340	41,660	37,830	0	8,333,040	
	Subcontractor MPR								590,340	
	SUBTOTAL								8,923,370	
	Project Management/Construction Mgnt								1,332,190	
	SUBTOTAL								10,255,570	
	General & Admin/Common Support Pool								2,604,430	
	SUBTOTAL								12,860,000	
	Contingency								4,501,000	
	TOTAL INCL OWNER COSTS								17,361,000	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis		42,100	0	0	0	0	0	42,100	
Off-Site Analytical Services		42,100	0	0	0	0	0	42,100	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work		29,420	5,590	2,430	190	180	0	37,820	
SUB:03 Site Work		22,180	4,210	1,830	150	130	0	28,510	
SUB:06 Groundwater Collection & Control		6,217,500	1,181,330	514,220	41,170	37,380	0	7,991,590	
SUB:20 Site Restoration		7,400	1,410	610	50	40	0	9,510	
SUB:21 Demobilization		15,060	2,860	1,250	100	90	0	19,350	
Fixed Price Contractor		6,291,560	1,195,400	520,340	41,660	37,830	0	8,086,790	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis		35,860	0	0	0	0	0	35,860	
WHC:06 Groundwater Collection & Control		2,300	0	0	0	0	0	2,300	
WHC:13 Slurry Wall		165,990	0	0	0	0	0	165,990	
Westinghouse Hanford Company		204,150	0	0	0	0	0	204,150	
HANFORD: ER PROGRAM		6,537,810	1,195,400	520,340	41,660	37,830	0	8,333,040	
Subcontractor MPR								590,340	
SUBTOTAL								8,923,370	
Project Management/Construction Mgnt								1,332,190	
SUBTOTAL								10,255,570	
General & Admin/Common Support Pool								2,604,430	
SUBTOTAL								12,860,000	
Contingency								4,501,000	
TOTAL INCL OWNER COSTS								17,361,000	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis									
ANA:02.08 Sampling Rad Contaminated Media									
ANA:02.08.02 Ground Water Analysis Yr 1 - 1									
Ground Water Analysis Yr 1	10.00 EA	42,100	0	0	0	0	0	42,100	4210.00
Sampling Rad Contaminated M		42,100	0	0	0	0	0	42,100	
Monitoring, Sampling & Anal		42,100	0	0	0	0	0	42,100	
Off-Site Analytical Service		42,100	0	0	0	0	0	42,100	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work									
SUB:01.02 Mobilize Personnel & Equipment									
SUB:01.02.02 Mobilize Trailers									
Mobilize Trailers		750	140	60	0	0	0	960	
Mobilize Personnel & Equipm		750	140	60	0	0	0	960	
SUB:01.04 Setup/Construct Temp Facilities									
SUB:01.04.01 Establish Facilities									
SUB:01.04.01.02 Setup Trailers		3,810	720	310	30	20	0	4,900	
Establish Facilities		3,810	720	310	30	20	0	4,900	
SUB:01.04.02 Construct Decon Area									
Construct Decon Area	24.00 HR	9,190	1,750	760	60	60	0	11,810	492.20
SUB:01.04.03 Site Survey									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Site Survey		1,000	190	80	10	10	0	1,290	
Setup/Construct Temp Facili		14,000	2,660	1,160	90	80	0	17,990	
SUB:01.05 Construct Temporary Utilities									
Construct Temporary Utiliti		4,680	890	390	30	30	0	6,010	
SUB:01.06 Pre-Construction Submittals									
Pre-Construction Submittals	4.00 EA	10,000	1,900	830	70	60	0	12,850	3213.35
Mobilization & Preparatory		29,420	5,590	2,430	190	180	0	37,820	
SUB:03 Site Work									
SUB:03.03 Earthwork									
Earthwork		5,000	950	410	30	30	0	6,430	
SUB:03.04 Roads/Parking/Curbs/Walks									
Roads/Parking/Curbs/Walks		7,180	1,360	590	50	40	0	9,230	
SUB:03.06 Electrical Distribution									
Electrical Distribution		10,000	1,900	830	70	60	0	12,850	
Site Work		22,180	4,210	1,830	150	130	0	28,510	
SUB:06 Groundwater Collection & Control									
SUB:06.01 Extraction & Injection Wells									
SUB:06.01.01 Well Drilling & Construction									
Well Drilling & Constructio	4.00 EA	480,000	91,200	39,700	3,180	2,890	0	616,960	154240.65
SUB:06.01.04 Operations and Maintenance 3,6									
Operations and Maintenance		46,000	8,740	3,800	300	280	0	59,130	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
SUB:06.01.9X Site Piping									
Site Piping		59,000	11,210	4,880	390	350	0	75,830	
Extraction & Injection Well		585,000	111,150	48,380	3,870	3,520	0	751,920	
SUB:06.03 Slurry Walls									
Slurry Walls		5,632,500	1,070,180	465,840	37,290	33,870	0	7,239,670	
Groundwater Collection & Co		6,217,500	1,181,330	514,220	41,170	37,380	0	7,991,590	
SUB:20 Site Restoration									
SUB:20.04 Revegetation and Planting									
Revegetation and Planting		7,400	1,410	610	50	40	0	9,510	
Site Restoration		7,400	1,410	610	50	40	0	9,510	
SUB:21 Demobilization									
SUB:21.02 Demobilize Personnel & Equipment									
SUB:21.02.02 Demobilize Trailers									
Demobilize Trailers		750	140	60	0	0	0	960	
Demobilize Personnel & Equi		750	140	60	0	0	0	960	
SUB:21.04 Demobilize Temp Facilities									
SUB:21.04.02 Remove Decon Area									
Remove Decon Area	8.00 HR	1,810	340	150	10	10	0	2,320	290.13
Demobilize Temp Facilities		1,810	340	150	10	10	0	2,320	
SUB:21.05 Disconnect Temporary Utilities									
Disconnect Temporary Utilit		2,500	480	210	20	20	0	3,210	
SUB:21.06 Post-Construction Submittals									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Post-Construction Submittal	4.00 EA	10,000	1,900	830	70	60	0	12,850	3213.35
Demobilization		15,060	2,860	1,250	100	90	0	19,350	
Fixed Price Contractor		6,291,560	1,195,400	520,340	41,660	37,830	0	8,086,790	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis									
WHC:02.08 Sampling Rad Contmntd Media 1-12									
WHC:02.08.02 Ground Water Analysis									
Ground Water Analysis	88.00 EA	35,200	0	0	0	0	0	35,200	400.00
WHC:02.08.04 Take Ground Water Samples									
Take Ground Water Samples	24.00 HR	660	0	0	0	0	0	660	27.62
Sampling Rad Contmntd Media		35,860	0	0	0	0	0	35,860	
Monitoring, Sampling & Anal		35,860	0	0	0	0	0	35,860	
WHC:06 Groundwater Collection & Control									
WHC:06.03 Slurry Walls 1 - 12									
Slurry Walls 1 - 12		2,300	0	0	0	0	0	2,300	
Groundwater Collection & Co		2,300	0	0	0	0	0	2,300	
WHC:13 Slurry Wall									
WHC:13.21 Slurry Wall									
WHC:13.21.08 Operation and Maint-Yrs 1-12									
Operation and Maint-Yrs 1-1		15,770	0	0	0	0	0	15,770	
WHC:13.21.11 Prepare Annual Report									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Prepare Annual Report		90,150	0	0	0	0	0	90,150	
WHC:13.21.12 Prepare Annual Report (Yrs 2-1									
Prepare Annual Report (Yrs		60,070	0	0	0	0	0	60,070	
Slurry Wall		165,990	0	0	0	0	0	165,990	
Slurry Wall		165,990	0	0	0	0	0	165,990	
Westinghouse Hanford Compan		204,150	0	0	0	0	0	204,150	
HANFORD: ER PROGRAM		6,537,810	1,195,400	520,340	41,660	37,830	0	8,333,040	
Subcontractor MPR								590,340	
SUBTOTAL								8,923,370	
Project Management/Construction Mgnt								1,332,190	
SUBTOTAL								10,255,570	
General & Admin/Common Support Pool								2,604,430	
SUBTOTAL								12,860,000	
Contingency								4,501,000	
TOTAL INCL OWNER COSTS								17,361,000	

		QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		0	0	0	42,100	42,100	
SUB	Fixed Price Contractor		13,550	2,920	7,010	6,268,080	6,291,560	
WHC	Westinghouse Hanford Company		153,190	0	0	50,970	204,150	
	HANFORD: ER PROGRAM		166,730	2,920	7,010	6,361,150	6,537,810	
	Overhead						1,195,400	
	SUBTOTAL						7,733,210	
	Profit						520,340	
	SUBTOTAL						8,253,550	
	Bond						41,660	
	SUBTOTAL						8,295,210	
	B&O Tax						37,830	
	TOTAL INCL INDIRECTS						8,333,040	
	Subcontractor MPR						590,340	
	SUBTOTAL						8,923,370	
	Project Management/Construction Mgnt						1,332,190	
	SUBTOTAL						10,255,570	
	General & Admin/Common Support Pool						2,604,430	
	SUBTOTAL						12,860,000	
	Contingency						4,501,000	
	TOTAL INCL OWNER COSTS						17,361,000	

** PROJECT DIRECT SUMMARY - LEVEL 2 (Rounded to 10's) **

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis		0	0	0	42,100	42,100	
Off-Site Analytical Services		0	0	0	42,100	42,100	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work		0	0	0	22,180	22,180	
SUB:06 Groundwater Collection & Control		0	0	0	6,217,500	6,217,500	
SUB:20 Site Restoration		0	0	0	7,400	7,400	
SUB:21 Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	6,268,080	6,291,560	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis		660	0	0	35,200	35,860	
WHC:06 Groundwater Collection & Control		2,300	0	0	0	2,300	
WHC:13 Slurry Wall		150,220	0	0	15,770	165,990	
Westinghouse Hanford Company		153,190	0	0	50,970	204,150	
HANFORD: ER PROGRAM		166,730	2,920	7,010	6,361,150	6,537,810	
Overhead						1,195,400	
SUBTOTAL						7,733,210	
Profit						520,340	
SUBTOTAL						8,253,550	
Bond						41,660	
SUBTOTAL						8,295,210	
B&O Tax						37,830	
TOTAL INCL INDIRECTS						8,333,040	
Subcontractor MPR						590,340	
SUBTOTAL						8,923,370	
Project Management/Construction Mgnt						1,332,190	
SUBTOTAL						10,255,570	
General & Admin/Common Support Pool						2,604,430	
SUBTOTAL						12,860,000	
Contingency						4,501,000	
TOTAL INCL OWNER COSTS						17,361,000	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis							
ANA:02.08 Sampling Rad Contaminated Media							
ANA:02.08.02 Ground Water Analysis Yr 1 - 12							
Ground Water Analysis Yr 1 - 12	10.00 EA	0	0	0	42,100	42,100	4210.00
Sampling Rad Contaminated Media		0	0	0	42,100	42,100	
Monitoring, Sampling & Analysis		0	0	0	42,100	42,100	
Off-Site Analytical Services		0	0	0	42,100	42,100	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work							
SUB:01.02 Mobilize Personnel & Equipment							
SUB:01.02.02 Mobilize Trailers							
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	
SUB:01.04 Setup/Construct Temp Facilities							
SUB:01.04.01 Establish Facilities							
SUB:01.04.01.02 Setup Trailers		3,000	0	810	0	3,810	
Establish Facilities		3,000	0	810	0	3,810	
SUB:01.04.02 Construct Decon Area							
Construct Decon Area	24.00 HR	4,350	1,070	3,770	0	9,190	382.93
SUB:01.04.03 Site Survey							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,350	1,070	4,580	1,000	14,000	
SUB:01.05 Construct Temporary Utilities							
Construct Temporary Utilities		2,250	0	2,430	0	4,680	
SUB:01.06 Pre-Construction Submittals							
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work							
SUB:03.03 Earthwork							
Earthwork		0	0	0	5,000	5,000	
SUB:03.04 Roads/Parking/Curbs/Walks							
Roads/Parking/Curbs/Walks		0	0	0	7,180	7,180	
SUB:03.06 Electrical Distribution							
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	22,180	22,180	
SUB:06 Groundwater Collection & Control							
SUB:06.01 Extraction & Injection Wells							
SUB:06.01.01 Well Drilling & Construction							
Well Drilling & Construction	4.00 EA	0	0	0	480,000	480,000	120000.00
SUB:06.01.04 Operations and Maintenance 3,6,9							
Operations and Maintenance 3,6,9		0	0	0	46,000	46,000	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.9X Site Piping							
Site Piping		0	0	0	59,000	59,000	
Extraction & Injection Wells		0	0	0	585,000	585,000	
SUB:06.03 Slurry Walls							
Slurry Walls		0	0	0	5,632,500	5,632,500	
Groundwater Collection & Control		0	0	0	6,217,500	6,217,500	
SUB:20 Site Restoration							
SUB:20.04 Revegetation and Planting							
Revegetation and Planting		0	0	0	7,400	7,400	
Site Restoration		0	0	0	7,400	7,400	
SUB:21 Demobilization							
SUB:21.02 Demobilize Personnel & Equipment							
SUB:21.02.02 Demobilize Trailers							
Demobilize Trailers		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	
SUB:21.04 Demobilize Temp Facilities							
SUB:21.04.02 Remove Decon Area							
Remove Decon Area	8.00 HR	1,450	360	0	0	1,810	225.72
Demobilize Temp Facilities		1,450	360	0	0	1,810	
SUB:21.05 Disconnect Temporary Utilities							
Disconnect Temporary Utilities		2,500	0	0	0	2,500	
SUB:21.06 Post-Construction Submittals							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	6,268,080	6,291,560	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis							
WHC:02.08 Sampling Rad Contmntd Media 1-12							
WHC:02.08.02 Ground Water Analysis							
Ground Water Analysis	88.00 EA	0	0	0	35,200	35,200	400.00
WHC:02.08.04 Take Ground Water Samples							
Take Ground Water Samples	24.00 HR	660	0	0	0	660	27.62
Sampling Rad Contmntd Media 1-12		660	0	0	35,200	35,860	
Monitoring, Sampling & Analysis		660	0	0	35,200	35,860	
WHC:06 Groundwater Collection & Control							
WHC:06.03 Slurry Walls 1 - 12							
Slurry Walls 1 - 12		2,300	0	0	0	2,300	
Groundwater Collection & Control		2,300	0	0	0	2,300	
WHC:13 Slurry Wall							
WHC:13.21 Slurry Wall							
WHC:13.21.08 Operation and Maint-Yrs 1-12							
Operation and Maint-Yrs 1-12		0	0	0	15,770	15,770	
WHC:13.21.11 Prepare Annual Report							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Prepare Annual Report		90,150	0	0	0	90,150	
WHC:13.21.12 Prepare Annual Report (Yrs 2-12)							
Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
Slurry Wall		150,220	0	0	15,770	165,990	
Slurry Wall		150,220	0	0	15,770	165,990	
Westinghouse Hanford Company		153,190	0	0	50,970	204,150	
HANFORD: ER PROGRAM		166,730	2,920	7,010	6,361,150	6,537,810	
Overhead						1,195,400	
SUBTOTAL						7,733,210	
Profit						520,340	
SUBTOTAL						8,253,550	
Bond						41,660	
SUBTOTAL						8,295,210	
B&O Tax						37,830	
TOTAL INCL INDIRECTS						8,333,040	
Subcontractor MPR						590,340	
SUBTOTAL						8,923,370	
Project Management/Construction Mgnt						1,332,190	
SUBTOTAL						10,255,570	
General & Admin/Common Support Pool						2,604,430	
SUBTOTAL						12,860,000	
Contingency						4,501,000	
TOTAL INCL OWNER COSTS						17,361,000	

ANA:02. Monitoring, Sampling & Analysis	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA. Off-Site Analytical Services
ANA:02. Monitoring, Sampling & Analysis
ANA:02.08. Sampling Rad Contaminated Media
ANA:02.08.02. Ground Water Analysis Yr 1 - 12

Assumptions:

1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle.
(14 samples)

2. Assume monthly performance monitoring of 7 wells for the 12-year lifecycle.
(84 samples)

 - Total samples = 98

3. All on-site sample analyses performed by WHC mobile lab

4. 10% off-site verification analysis of reduced analyte list with CLP protocol.
(10% of 98 = 10 ea)

	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Analyze LLW Sample - Off-site			0.00	0.00	0.00	4210.00	4210.00	
Lab	10.00 EA		0	0	0	42,100	42,100	4210.00
Ground Water Analysis Yr 1 - 12	10.00 EA		0	0	0	42,100	42,100	4210.00
Sampling Rad Contaminated Media			0	0	0	42,100	42,100	
Monitoring, Sampling & Analysis			0	0	0	42,100	42,100	
Off-Site Analytical Services			0	0	0	42,100	42,100	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB. Fixed Price Contractor							
SUB:01. Mobilization & Preparatory Work							
SUB:01.02. Mobilize Personnel & Equipment							
SUB:01.02.02. Mobilize Trailers							
FPC S3 Mobilize Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04. Setup/Construct Temp Facilities							
SUB:01.04.01. Establish Facilities							
SUB:01.04.01.02. Setup Trailers							
M FPC S3 Setup Field Office Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Storage Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Decon Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
Setup Trailers		3,000	0	809	0	3,809	
Establish Facilities		3,000	0	809	0	3,809	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.02. Construct Decon Area Work to be Performed: Construct decontamination area/pad for equipment and vehicles. Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Output: Assumed duration for this activity is 3 crew days.								
FPC S3 Laborer Group - 1 - 3 ea	72.00 HR	0029	25.20 1,814	0.00 0	0.00 0	0.00 0	25.20 1,814	25.20
FPC S3 Laborer Group - 2 - 3 ea	72.00 HR	0030	25.50 1,836	0.00 0	0.00 0	0.00 0	25.50 1,836	25.50
FPC S3 Group-6 Power Equipment Operator - 1 ea	24.00 HR	0039	29.10 698	0.00 0	0.00 0	0.00 0	29.10 698	29.10
FPC S3 Small Tools - 2 ea	48.00 HR	XMIXX020	0.00 0	1.39 67	0.00 0	0.00 0	1.39 67	1.39
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW 4X4 3/4 TON PICK-UP - 1 ea	24.00 HR	T50F0004	0.00 0	7.31 175	0.00 0	0.00 0	7.31 175	7.31
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4 HYDRO-SCOPIC - 1 ea	24.00 HR	H30BA001	0.00 0	34.44 826	0.00 0	0.00 0	34.44 826	34.44
M FPC S3 Construction Materials/Supplies Allowance	1.00 LS		0.00 0	0.00 0	2156.00 2,156	0.00 0	2156.00 2,156	2156.00
M FPC S3 Allowance for Tank Assume 1000 gal plastic tank for water collection	1.00 EA		0.00 0	0.00 0	1617.00 1,617	0.00 0	1617.00 1,617	1617.00
Construct Decon Area	24.00 HR		4,349	1,069	3,773	0	9,190	382.93

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.03. Site Survey							
FPC S3 Allowance for Site Survey		0.00	0.00	0.00	1000.00	1000.00	
Prepare site for construction	1.00 LS	0	0	0	1,000	1,000	1000.00
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,349	1,069	4,582	1,000	13,999	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.05. Construct Temporary Utilities							
M FPC S3 Allowance for Temporary Power		1.00	0.00	1.08	0.00	2.08	
	500.00 LF	500	0	539	0	1,039	2.08
M FPC S3 Allowance for Telephone		0.50	0.00	0.54	0.00	1.04	
	500.00 LF	250	0	270	0	520	1.04
M FPC S3 Allowance for Temporary Water		3.00	0.00	3.23	0.00	6.23	
and Sewer Service	500.00 LF	1,500	0	1,617	0	3,117	6.23
Construct Temporary Utilities		2,250	0	2,426	0	4,676	

Fri 07 Oct 1994
DETAILED ESTIMATE

U.S. Army Corps of Engineers
PROJECT BSLRRY: HANFORD: ER PROGRAM - 100 BC-5 SLURRY WALL
VERTICAL BARRIER MODEL
SUB. Fixed Price Contractor

TIME 07:12:44
DETAIL PAGE 7

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.06. Pre-Construction Submittals							
FPC S3 Allowance for Pre-Construction Submittals by Fixed Price Contractor	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,599	1,819	7,007	11,000	29,424	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03. Site Work							
SUB:03.03. Earthwork							
FPC S3 Allowance for Site Preparation		0.00	0.00	0.00	5000.00	5000.00	
	1.00 LS	0	0	0	5,000	5,000	5000.00
Earthwork		0	0	0	5,000	5,000	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.04. Roads/Parking/Curbs/Walks							
FPC S3 Allowance for Access Road		0.00	0.00	0.00	10.00	10.00	
	400.00 SY	0	0	0	4,000	4,000	10.00
FPC S3 Access Roads to Wells		0.00	0.00	0.00	2.12	2.12	
Assume 750 lf of road per well, 10 ft wide, native materials 750 lf/well x 2 wells = 1500 lf	1500.00 LF	0	0	0	3,180	3,180	2.12
Roads/Parking/Curbs/Walks		0	0	0	7,180	7,180	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.06. Electrical Distribution							
FPC S3 Allowance for Site Electrical		0.00	0.00	0.00	10000.00	10000.00	
	1.00 LS	0	0	0	10,000	10,000	10000.00
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	22,180	22,180	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06. Groundwater Collection & Control SUB:06.01. Extraction & Injection Wells SUB:06.01.01. Well Drilling & Construction							
FPC S3 Drill/Inst Extr/Inject Wells Note: 2 new extraction and 2 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and packaging of contaminated well cuttings, transport to the disposal facility, and associated disposal fees.	600.00 LF	0.00 0	0.00 0	0.00 0	700.00 420,000	700.00 420,000	700.00
FPC S3 Allowance for Well Pumps-100 GPM	2.00 EA	0.00 0	0.00 0	0.00 0	3000.00 6,000	3000.00 6,000	3000.00
FPC S3 Allowance for Controls and connections at wellheads	4.00 EA	0.00 0	0.00 0	0.00 0	10000.00 40,000	10000.00 40,000	10000.00
FPC S3 Allowance for Water Level monitoring instrumentation. Assume 5 piezometers per extraction well using well points	10.00	0.00 0	0.00 0	0.00 0	1000.00 10,000	1000.00 10,000	1000.00
FPC S3 Allowance for Wellhead Covers Assume manhole-type cover for each wellhead	4.00 EA	0.00 0	0.00 0	0.00 0	1000.00 4,000	1000.00 4,000	1000.00
Well Drilling & Construction	4.00 EA	0	0	0	480,000	480,000	120000.00

Fri 07 Oct 1994 U.S. Army Corps of Engineers TIME 07:12:44

PROJECT BSLRRY: HANFORD: ER PROGRAM - 100 BC-5 SLURRY WALL

DETAILED ESTIMATE VERTICAL BARRIER MODEL DETAIL PAGE 12

SUB. Fixed Price Contractor

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.04. Operations and Maintenance 3,6,9							
FPC S3 Allowance for Well Workover		0.00	0.00	0.00	10000.00	10000.00	
Assume 1 every 3 years for each well during the 12-year lifecycle	4.00 EA	0	0	0	40,000	40,000	10000.00
FPC S3 Allowance for Well Pump		0.00	0.00	0.00	3000.00	3000.00	
Replacement Assume pump replacement every 3 years for each extraction well	2.00 EA	0	0	0	6,000	6,000	3000.00
Operations and Maintenance 3,6,9		0	0	0	46,000	46,000	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.9X. Site Piping							
FPC S3 Allowance for Piping from Well Head to distribution point Assume 750 lf of double-wall PVC pipe per extraction well	1500.00 LF	0.00 0	0.00 0	0.00 0	18.00 27,000	18.00 27,000	18.00
FPC S3 Allowance for Leak Detection	1.00 LS	0.00 0	0.00 0	0.00 0	5000.00 5,000	5000.00 5,000	5000.00
FPC S3 Allowance for Force Main Discharge Piping Assume 750 lf of double-wall PVC piping per injection well	1500.00 LF	0.00 0	0.00 0	0.00 0	18.00 27,000	18.00 27,000	18.00
Site Piping		0	0	0	59,000	59,000	
Extraction & Injection Wells		0	0	0	585,000	585,000	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.03. Slurry Walls							
FPC S3 Construct Slurry Wall		0.00	0.00	0.00	25.00	25.00	
Assume 150 ft deep x 1500 lf Includes mob of equipment, excavation, and installation of slurry wall.	225000 SF	0	0	0	5,625,000	5,625,000	25.00
FPC S3 Install Soil Cap over Barrier		0.00	0.00	0.00	5.00	5.00	
	1500.00 LF	0	0	0	7,500	7,500	5.00
Slurry Walls		0	0	0	5,632,500	5,632,500	
Groundwater Collection & Control		0	0	0	6,217,500	6,217,500	

SUB:20. Site Restoration	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:20. Site Restoration							
SUB:20.04. Revegetation and Planting							
FPC S3 Allowance for Site Restoration		0.00	0.00	0.00	2.00	2.00	
	3700.00 SY	0	0	0	7,400	7,400	2.00
Revegetation and Planting		0	0	0	7,400	7,400	
Site Restoration		0	0	0	7,400	7,400	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21. Demobilization							
SUB:21.02. Demobilize Personnel & Equipment							
SUB:21.02.02. Demobilize Trailers							
FPC S3 Demob Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Demobilize Trailers		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.04. Demobilize Temp Facilities							
SUB:21.04.02. Remove Decon Area							
Work to be Performed: Remove decontamination area/pad for equipment and vehicles. Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Output: Assumed duration for this activity is 1 crew day.							
FPC S3 Group-6 Power Equipment Operator - 1 ea	8.00 HR 0039	29.10 233	0.00 0	0.00 0	0.00 0	29.10 233	29.10
FPC S3 Laborer Group - 1 - 3 ea	24.00 HR 0029	25.20 605	0.00 0	0.00 0	0.00 0	25.20 605	25.20
FPC S3 Laborer Group - 2 - 3 ea	24.00 HR 0030	25.50 612	0.00 0	0.00 0	0.00 0	25.50 612	25.50
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4 HYDRO-SCOPIC - 1 ea	8.00 HR H30BA001	0.00 0	34.44 275	0.00 0	0.00 0	34.44 275	34.44
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW 4X4 3/4 TON PICK-UP - 1 ea	8.00 HR T50F0004	0.00 0	7.31 58	0.00 0	0.00 0	7.31 58	7.31
FPC S3 Small Tools - 2 ea	16.00 HR XMIXX020	0.00 0	1.39 22	0.00 0	0.00 0	1.39 22	1.39
Remove Decon Area	8.00 HR	1,450	356	0	0	1,806	225.72
Demobilize Temp Facilities		1,450	356	0	0	1,806	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.05. Disconnect Temporary Utilities							
M FPC S3 Remove Temporary Power		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Telephone		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Temporary Water		3.00	0.00	0.00	0.00	3.00	
and Sewer Service	500.00 LF	1,500	0	0	0	1,500	3.00
Disconnect Temporary Utilities		2,500	0	0	0	2,500	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.06. Post-Construction Submittals							
FPC S3 Allowance for Post-Construction Submittals by Fixed Price Contractor, Year 12	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,106	0	10,000	15,056	
Fixed Price Contractor		13,548	2,925	7,007	6,268,080	6,291,560	

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC. Westinghouse Hanford Company							
WHC:02. Monitoring, Sampling & Analysis							
WHC:02.08. Sampling Rad Contmntd Media 1-12							
WHC:02.08.02. Ground Water Analysis							
WHC Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
	88.00 EA	0	0	0	35,200	35,200	400.00
Ground Water Analysis	88.00 EA	0	0	0	35,200	35,200	400.00

Assumptions:

1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle.
   (14 samples)

2. Assume monthly performance monitoring of 7 wells for the 12-year lifecycle.
   (84 samples)

   - Total samples = 98

3. 90% of samples analyzed at mobile lab
   (90% of 98 = 88)

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:02.08.04. Take Ground Water Samples Assumptions: 1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples) 2. Assume 2 field technicians for 6 hours on a semiannual basis for the 12-year lifecycle (24 hours)							
WHC Technician, Environmental Restoration Ops - 2 ea	24.00 HR 85201	27.62 663	0.00 0	0.00 0	0.00 0	27.62 663	27.62
Take Ground Water Samples	24.00 HR	663	0	0	0	663	27.62
Sampling Rad Contmntd Media 1-12		663	0	0	35,200	35,863	
Monitoring, Sampling & Analysis		663	0	0	35,200	35,863	

WHC:06. Groundwater Collection & Control		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:06. Groundwater Collection & Control								
WHC:06.03. Slurry Walls 1 - 12								
Assume WHC QA and safety oversite for the construction project.								
WHC	Technician, Environmental		28.80	0.00	0.00	0.00	28.80	
	Restoration Ops	80.00 HR 85201	2,304	0	0	0	2,304	28.80
	Slurry Walls 1 - 12		2,304	0	0	0	2,304	
	Groundwater Collection & Control		2,304	0	0	0	2,304	

WHC:13. Slurry Wall	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13. Slurry Wall							
WHC:13.21. Slurry Wall							
WHC:13.21.08. Operation and Maint-Yrs 1-12							
WHC Allowance for Electricity		0.00	0.00	0.00	0.06	0.06	
Wells: 720 kW-hr/d	262800 KW	0	0	0	15,768	15,768	0.06
Assume 24 hrs/d x 365 days/yr							
for the 12-year lifecycle							
Operation and Maint-Yrs 1-12		0	0	0	15,768	15,768	

WHC:13. Slurry Wall		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13.21.11. Prepare Annual Report									
WHC	Engineer, Environmental Restoration Ops	1040.00 HR	85101	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
WHC	Scientist, Environmental Restoration Ops	1040.00 HR	85102	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
	Prepare Annual Report			90,148	0	0	0	90,148	

WHC:13. Slurry Wall		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
	WHC:13.21.12. Prepare Annual Report (Yrs 2-12) Assume 66% Year 1 Annual Report effort (2 FTE's for 4 months each year)							
WHC	Engineer, Environmental Restoration Ops	693.00 HR 85101	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
WHC	Scientist, Environmental Restoration Ops	693.00 HR 85102	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
	Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
	Slurry Wall		150,218	0	0	15,768	165,986	
	Slurry Wall		150,218	0	0	15,768	165,986	
	Westinghouse Hanford Company		153,185	0	0	50,968	204,153	
	HANFORD: ER PROGRAM		166,734	2,925	7,007	6,361,148	6,537,814	

** LABOR BACKUP **

SRC LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
FPC 0029	Laborer Group - 1	15.84	0.0%	28.7%	3.57	1.25	25.20	HR	07/09/93	0.00	96
FPC 0030	Laborer Group - 2	16.09	0.0%	28.5%	3.57	1.25	25.50	HR	07/09/93	0.00	96
FPC 0039	Group-6 Power Equipment Operator	18.02	0.0%	27.4%	4.90	1.25	29.10	HR	07/09/93	0.00	32
WHC 85101	Engineer, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85102	Scientist, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85201	Technician, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	104

SRC EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL UOM	** TOTAL ** HOURS
MIL H30BA001	HYD EXCAV,TRK MTD,.5 CY BKT,6X4	14.36	3.58	4.07	1.4	9.83	0.98	0.15	34.44 HR	32
MIL T50FO004	TRK,HWY,4X4,F250,3/4T,8800 GVW	1.58	0.39	2.67	0.7	1.60	0.27	0.04	7.31 HR	32
MIL XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39 HR	64

HANFORD: ER PROGRAM
100 BC-5 ION EXCHANGE
1.4.10.1.1.10.5.2.4
ION EXCHANGE REMEDIATION
PRELIMINARY COST MODEL

Designed By:
Estimated By: IT Corporation

Prepared By: USACE/CENPW COST ENG BRANCH
Project Time & Cost, Inc.

Date: 10/07/94

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

Fri 07 Oct 1994 U.S. Army Corps of Engineers TIME 07:11:16
PROJECT BAREIX: HANFORD: ER PROGRAM - 100 BC-5 ION EXCHANGE
100 BC-5 ION EXCHANGE REMEDIATION MODEL SUMMARY PAGE 1
** PROJECT OWNER SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		54,730	0	0	0	19,160	73,890	
SUB	Fixed Price Contractor		1,971,350	143,910	317,290	620,300	1,068,490	4,121,340	
WHC	Westinghouse Hanford Company		835,020	0	125,250	244,870	421,800	1,626,940	
	HANFORD: ER PROGRAM		2,861,100	143,910	442,540	865,170	1,509,450	5,822,170	

Fri 07 Oct 1994

U.S. Army Corps of Engineers
PROJECT BAREIX: HANFORD: ER PROGRAM - 100 BC-5 ION EXCHANGE
100 BC-5 ION EXCHANGE REMEDIATION MODEL
** PROJECT OWNER SUMMARY - LEVEL 2 (Rounded to 10's) **

TIME 07:11:16

SUMMARY PAGE 2

		QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services								
ANA:02	Monitoring, Sampling & Analysis		54,730	0	0	0	19,160	73,890	
	Off-Site Analytical Services		54,730	0	0	0	19,160	73,890	
SUB	Fixed Price Contractor								
SUB:01	Mobilization & Preparatory Work		37,990	2,770	6,110	11,950	20,590	79,420	
SUB:03	Site Work		54,700	3,990	8,800	17,210	29,650	114,370	
SUB:06	Groundwater Collection & Control		1,544,180	112,730	248,540	485,890	836,960	3,228,290	
SUB:12	Chemical Treatment		302,120	22,050	48,630	95,060	163,750	631,620	
SUB:20	Site Restoration		12,910	940	2,080	4,060	7,000	26,990	
SUB:21	Demobilization		19,440	1,420	3,130	6,120	10,540	40,640	
	Fixed Price Contractor		1,971,350	143,910	317,290	620,300	1,068,490	4,121,340	
WHC	Westinghouse Hanford Company								
WHC:02	Monitoring, Sampling & Analysis		46,650	0	7,000	13,680	23,570	90,900	
WHC:12	Chemical Treatment		788,370	0	118,260	231,190	398,230	1,536,050	
	Westinghouse Hanford Company		835,020	0	125,250	244,870	421,800	1,626,940	
	HANFORD: ER PROGRAM		2,861,100	143,910	442,540	865,170	1,509,450	5,822,170	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis								
ANA:02.08 Sampling Rad Contaminated Media								
ANA:02.08.02 Ground Water Analysis Yr - 1								
Ground Water Analysis Yr - 1	9.00 EA	37,890	0	0	0	13,260	51,150	5683.50
ANA:02.08.03 Ground Water Analysis Yrs 2-12								
Ground Water Analysis Yrs 2-12	4.00 EA	16,840	0	0	0	5,890	22,730	5683.50
Sampling Rad Contaminated Media		54,730	0	0	0	19,160	73,890	
Monitoring, Sampling & Analysis		54,730	0	0	0	19,160	73,890	
Off-Site Analytical Services		54,730	0	0	0	19,160	73,890	
SUB Fixed Price Contractor								
SUB:01 Mobilization & Preparatory Work								
SUB:01.02 Mobilize Personnel & Equipment								
SUB:01.02.02 Mobilize Trailers								
Mobilize Trailers		970	70	160	300	520	2,020	
Mobilize Personnel & Equipment		970	70	160	300	520	2,020	
SUB:01.04 Setup/Construct Temp Facilities								
SUB:01.04.01 Establish Facilities								
SUB:01.04.01.02 Setup Trailers		4,920	360	790	1,550	2,670	10,280	
Establish Facilities		4,920	360	790	1,550	2,670	10,280	
SUB:01.04.02 Construct Decon Area								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	11,870	870	1,910	3,730	6,430	24,810	1033.63
SUB:01.04.03 Site Survey								
Site Survey		1,290	90	210	410	700	2,700	
Setup/Construct Temp Facilities		18,070	1,320	2,910	5,690	9,800	37,790	
SUB:01.05 Construct Temporary Utilities								
Construct Temporary Utilities		6,040	440	970	1,900	3,270	12,620	
SUB:01.06 Pre-Construction Submittals								
Pre-Construction Submittals	4.00 EA	12,910	940	2,080	4,060	7,000	26,990	6748.10
Mobilization & Preparatory Work		37,990	2,770	6,110	11,950	20,590	79,420	
SUB:03 Site Work								
SUB:03.03 Earthwork								
Earthwork		6,460	470	1,040	2,030	3,500	13,500	
SUB:03.04 Roads/Parking/Curbs/Walks								
Roads/Parking/Curbs/Walks		25,460	1,860	4,100	8,010	13,800	53,230	
SUB:03.05 Fencing								
Fencing		9,880	720	1,590	3,110	5,350	20,650	
SUB:03.06 Electrical Distribution								
Electrical Distribution		12,910	940	2,080	4,060	7,000	26,990	
Site Work		54,700	3,990	8,800	17,210	29,650	114,370	
SUB:06 Groundwater Collection & Control								
SUB:06.01 Extraction & Injection Wells								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction								
Well Drilling & Construction	8.00 EA	1,291,120	94,250	207,810	406,260	699,800	2,699,240	337405.22
SUB:06.01.04 Operations and Maintenance 3,6,9								
Operations and Maintenance 3,6,9		118,780	8,670	19,120	37,380	64,380	248,330	
SUB:06.01.9X Site Piping								
Site Piping		134,280	9,800	21,610	42,250	72,780	280,720	
Extraction & Injection Wells		1,544,180	112,730	248,540	485,890	836,960	3,228,290	
Groundwater Collection & Control		1,544,180	112,730	248,540	485,890	836,960	3,228,290	
SUB:12 Chemical Treatment								
SUB:12.05 Ion Exchange								
SUB:12.05.04 Construction of Permanent Plant								
Construction of Permanent Plant	600.00 SF	302,120	22,050	48,630	95,060	163,750	631,620	1052.70
Ion Exchange		302,120	22,050	48,630	95,060	163,750	631,620	
Chemical Treatment		302,120	22,050	48,630	95,060	163,750	631,620	
SUB:20 Site Restoration								
SUB:20.04 Revegetation and Planting								
Revegetation and Planting		12,910	940	2,080	4,060	7,000	26,990	
Site Restoration		12,910	940	2,080	4,060	7,000	26,990	
SUB:21 Demobilization								
SUB:21.02 Demobilize Personnel & Equipment								
SUB:21.02.02 Demobilize Trailers								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Demobilize Trailers		970	70	160	300	520	2,020	
Demobilize Personnel & Equipment		970	70	160	300	520	2,020	
SUB:21.04 Demobilize Temp Facilities								
SUB:21.04.02 Remove Decon Area								
Remove Decon Area	8.00 HR	2,330	170	380	730	1,260	4,870	609.28
Demobilize Temp Facilities		2,330	170	380	730	1,260	4,870	
SUB:21.05 Disconnect Temporary Utilities								
Disconnect Temporary Utilities		3,230	240	520	1,020	1,750	6,750	
SUB:21.06 Post-Construction Submittals								
Post-Construction Submittals	4.00 EA	12,910	940	2,080	4,060	7,000	26,990	6748.10
Demobilization		19,440	1,420	3,130	6,120	10,540	40,640	
Fixed Price Contractor		1,971,350	143,910	317,290	620,300	1,068,490	4,121,340	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis								
WHC:02.08 Sampling Rad Contaminated Media								
WHC:02.08.02 Ground Water Analysis Yr - 1								
Ground Water Analysis Yr - 1	77.00 EA	31,610	0	4,740	9,270	15,970	61,580	799.76
WHC:02.08.03 Ground Water Analysis Yr 2 - 12								
Ground Water Analysis Yr 2 - 12	34.00 EA	14,380	0	2,160	4,220	7,270	28,020	824.20
WHC:02.08.04 Ground Water Monitor Smples 1-12								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Ground Water Monitor Smples 1-12	24.00 HR	660	0	100	190	330	1,290	53.82
Sampling Rad Contaminated Media		46,650	0	7,000	13,680	23,570	90,900	
Monitoring, Sampling & Analysis		46,650	0	7,000	13,680	23,570	90,900	
WHC:12 Chemical Treatment								
WHC:12.05 Ion Exchange								
WHC:12.05.06 Personnel Training								
Personnel Training		6,900	0	1,040	2,020	3,490	13,450	
WHC:12.05.08 Operation & Maintenance Yrs 1-12								
Operation & Maintenance Yrs 1-12	1.00 YR	631,250	0	94,690	185,110	318,870	1,229,910	1229910.42
WHC:12.05.11 Prepare Annual Report (Yr 1)								
Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	13,520	26,440	45,540	175,640	84.44
WHC:12.05.12 Prepare Annual Report (Yrs 2-12)								
Prepare Annual Report (Yrs 2-12)		60,070	0	9,010	17,620	30,340	117,040	
Ion Exchange		788,370	0	118,260	231,190	398,230	1,536,050	
Chemical Treatment		788,370	0	118,260	231,190	398,230	1,536,050	
Westinghouse Hanford Company		835,020	0	125,250	244,870	421,800	1,626,940	
HANFORD: ER PROGRAM		2,861,100	143,910	442,540	865,170	1,509,450	5,822,170	

** PROJECT INDIRECT SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		54,730	0	0	0	0	0	54,730	
SUB	Fixed Price Contractor		1,526,850	290,100	131,730	13,440	9,220	0	1,971,350	
WHC	Westinghouse Hanford Company		827,110	0	0	0	0	7,910	835,020	
	HANFORD: ER PROGRAM		2,408,690	290,100	131,730	13,440	9,220	7,910	2,861,100	
	Subcontractor MPR								143,910	
	SUBTOTAL								3,005,010	
	Project Management/Construction Mgnt								442,540	
	SUBTOTAL								3,447,550	
	General & Admin/Common Support Pool								865,170	
	SUBTOTAL								4,312,720	
	Contingency								1,509,450	
	TOTAL INCL OWNER COSTS								5,822,170	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis		54,730	0	0	0	0	0	54,730	
Off-Site Analytical Services		54,730	0	0	0	0	0	54,730	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work		29,420	5,590	2,540	260	180	0	37,990	
SUB:03 Site Work		42,370	8,050	3,660	370	260	0	54,700	
SUB:06 Groundwater Collection & Control		1,196,000	227,240	103,180	10,530	7,220	0	1,544,180	
SUB:12 Chemical Treatment		234,000	44,460	20,190	2,060	1,410	0	302,120	
SUB:20 Site Restoration		10,000	1,900	860	90	60	0	12,910	
SUB:21 Demobilization		15,060	2,860	1,300	130	90	0	19,440	
Fixed Price Contractor		1,526,850	290,100	131,730	13,440	9,220	0	1,971,350	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis		46,650	0	0	0	0	0	46,650	
WHC:12 Chemical Treatment		780,460	0	0	0	0	7,910	788,370	
Westinghouse Hanford Company		827,110	0	0	0	0	7,910	835,020	
HANFORD: ER PROGRAM		2,408,690	290,100	131,730	13,440	9,220	7,910	2,861,100	
Subcontractor MPR								143,910	
SUBTOTAL								3,005,010	
Project Management/Construction Mgnt								442,540	
SUBTOTAL								3,447,550	
General & Admin/Common Support Pool								865,170	
SUBTOTAL								4,312,720	
Contingency								1,509,450	
TOTAL INCL OWNER COSTS								5,822,170	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis									
ANA:02.08 Sampling Rad Contaminated Media									
ANA:02.08.02 Ground Water Analysis Yr - 1									
Ground Water Analysis Yr -	9.00 EA	37,890	0	0	0	0	0	37,890	4210.00
ANA:02.08.03 Ground Water Analysis Yrs 2-12									
Ground Water Analysis Yrs 2	4.00 EA	16,840	0	0	0	0	0	16,840	4210.00
Sampling Rad Contaminated M		54,730	0	0	0	0	0	54,730	
Monitoring, Sampling & Anal		54,730	0	0	0	0	0	54,730	
Off-Site Analytical Service		54,730	0	0	0	0	0	54,730	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work									
SUB:01.02 Mobilize Personnel & Equipment									
SUB:01.02.02 Mobilize Trailers									
Mobilize Trailers		750	140	60	10	0	0	970	
Mobilize Personnel & Equipm		750	140	60	10	0	0	970	
SUB:01.04 Setup/Construct Temp Facilities									
SUB:01.04.01 Establish Facilities									
SUB:01.04.01.02 Setup Trailers		3,810	720	330	30	20	0	4,920	
Establish Facilities		3,810	720	330	30	20	0	4,920	
SUB:01.04.02 Construct Decon Area									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	9,190	1,750	790	80	60	0	11,870	494.41
SUB:01.04.03 Site Survey									
Site Survey		1,000	190	90	10	10	0	1,290	
Setup/Construct Temp Facili		14,000	2,660	1,210	120	80	0	18,070	
SUB:01.05 Construct Temporary Utilities									
Construct Temporary Utiliti		4,680	890	400	40	30	0	6,040	
SUB:01.06 Pre-Construction Submittals									
Pre-Construction Submittals	4.00 EA	10,000	1,900	860	90	60	0	12,910	3227.80
Mobilization & Preparatory		29,420	5,590	2,540	260	180	0	37,990	
SUB:03 Site Work									
SUB:03.03 Earthwork									
Earthwork		5,000	950	430	40	30	0	6,460	
SUB:03.04 Roads/Parking/Curbs/Walks									
Roads/Parking/Curbs/Walks		19,720	3,750	1,700	170	120	0	25,460	
SUB:03.05 Fencing									
Fencing		7,650	1,450	660	70	50	0	9,880	
SUB:03.06 Electrical Distribution									
Electrical Distribution		10,000	1,900	860	90	60	0	12,910	
Site Work		42,370	8,050	3,660	370	260	0	54,700	
SUB:06 Groundwater Collection & Control									
SUB:06.01 Extraction & Injection Wells									

	QUANTITY	UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction										
Well Drilling & Constructio	8.00	EA	1,000,000	190,000	86,270	8,810	6,040	0	1,291,120	161390.05
SUB:06.01.04 Operations and Maintenance 3,6										
Operations and Maintenance			92,000	17,480	7,940	810	560	0	118,780	
SUB:06.01.9X Site Piping										
Site Piping			104,000	19,760	8,970	920	630	0	134,280	
Extraction & Injection Well			1,196,000	227,240	103,180	10,530	7,220	0	1,544,180	
Groundwater Collection & Co			1,196,000	227,240	103,180	10,530	7,220	0	1,544,180	
SUB:12 Chemical Treatment										
SUB:12.05 Ion Exchange										
SUB:12.05.04 Construction of Permanent Plan										
Construction of Permanent P	600.00	SF	234,000	44,460	20,190	2,060	1,410	0	302,120	503.54
Ion Exchange			234,000	44,460	20,190	2,060	1,410	0	302,120	
Chemical Treatment			234,000	44,460	20,190	2,060	1,410	0	302,120	
SUB:20 Site Restoration										
SUB:20.04 Revegetation and Planting										
Revegetation and Planting			10,000	1,900	860	90	60	0	12,910	
Site Restoration			10,000	1,900	860	90	60	0	12,910	
SUB:21 Demobilization										
SUB:21.02 Demobilize Personnel & Equipment										
SUB:21.02.02 Demobilize Trailers										

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Demobilize Trailers		750	140	60	10	0	0	970	
Demobilize Personnel & Equi		750	140	60	10	0	0	970	
SUB:21.04 Demobilize Temp Facilities									
SUB:21.04.02 Remove Decon Area									
Remove Decon Area	8.00 HR	1,810	340	160	20	10	0	2,330	291.44
Demobilize Temp Facilities		1,810	340	160	20	10	0	2,330	
SUB:21.05 Disconnect Temporary Utilities									
Disconnect Temporary Utilit		2,500	480	220	20	20	0	3,230	
SUB:21.06 Post-Construction Submittals									
Post-Construction Submittal	4.00 EA	10,000	1,900	860	90	60	0	12,910	3227.80
Demobilization		15,060	2,860	1,300	130	90	0	19,440	
Fixed Price Contractor		1,526,850	290,100	131,730	13,440	9,220	0	1,971,350	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis									
WHC:02.08 Sampling Rad Contaminated Media									
WHC:02.08.02 Ground Water Analysis Yr - 1									
Ground Water Analysis Yr -	77.00 EA	31,610	0	0	0	0	0	31,610	410.47
WHC:02.08.03 Ground Water Analysis Yr 2 - 1									
Ground Water Analysis Yr 2	34.00 EA	14,380	0	0	0	0	0	14,380	423.01
WHC:02.08.04 Ground Water Monitor Smples 1-									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Ground Water Monitor Smples	24.00 HR	660	0	0	0	0	0	660	27.62
Sampling Rad Contaminated M		46,650	0	0	0	0	0	46,650	
Monitoring, Sampling & Anal		46,650	0	0	0	0	0	46,650	
WHC:12 Chemical Treatment									
WHC:12.05 Ion Exchange									
WHC:12.05.06 Personnel Training									
Personnel Training		6,900	0	0	0	0	0	6,900	
WHC:12.05.08 Operation & Maintenance Yrs 1-									
Operation & Maintenance Yrs	1.00 YR	623,330	0	0	0	0	7,910	631,250	631245.28
WHC:12.05.11 Prepare Annual Report (Yr 1)									
Prepare Annual Report (Yr 1	2080.00 HR	90,150	0	0	0	0	0	90,150	43.34
WHC:12.05.12 Prepare Annual Report (Yrs 2-1									
Prepare Annual Report (Yrs		60,070	0	0	0	0	0	60,070	
Ion Exchange		780,460	0	0	0	0	7,910	788,370	
Chemical Treatment		780,460	0	0	0	0	7,910	788,370	
Westinghouse Hanford Compan		827,110	0	0	0	0	7,910	835,020	
HANFORD: ER PROGRAM		2,408,690	290,100	131,730	13,440	9,220	7,910	2,861,100	
Subcontractor MPR								143,910	
SUBTOTAL								3,005,010	
Project Management/Construction Mgnt								442,540	
SUBTOTAL								3,447,550	
General & Admin/Common Support Pool								865,170	
SUBTOTAL								4,312,720	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Contingency								1,509,450	
TOTAL INCL OWNER COSTS								5,822,170	

		QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		0	0	0	54,730	54,730	
SUB	Fixed Price Contractor		13,550	2,920	7,010	1,503,370	1,526,850	
WHC	Westinghouse Hanford Company		691,500	0	52,050	83,560	827,110	
	HANFORD: ER PROGRAM		705,050	2,920	59,050	1,641,660	2,408,690	
	Overhead						290,100	
	SUBTOTAL						2,698,790	
	Profit						131,730	
	SUBTOTAL						2,830,520	
	Bond						13,440	
	SUBTOTAL						2,843,960	
	B&O Tax						9,220	
	SUBTOTAL						2,853,190	
	Material/Supply MPR						7,910	
	TOTAL INCL INDIRECTS						2,861,100	
	Subcontractor MPR						143,910	
	SUBTOTAL						3,005,010	
	Project Management/Construction Mgnt						442,540	
	SUBTOTAL						3,447,550	
	General & Admin/Common Support Pool						865,170	
	SUBTOTAL						4,312,720	
	Contingency						1,509,450	
	TOTAL INCL OWNER COSTS						5,822,170	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis		0	0	0	54,730	54,730	
Off-Site Analytical Services		0	0	0	54,730	54,730	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work		0	0	0	42,370	42,370	
SUB:06 Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	
SUB:12 Chemical Treatment		0	0	0	234,000	234,000	
SUB:20 Site Restoration		0	0	0	10,000	10,000	
SUB:21 Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	1,503,370	1,526,850	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis		660	0	0	45,990	46,650	
WHC:12 Chemical Treatment		690,840	0	52,050	37,570	780,460	
Westinghouse Hanford Company		691,500	0	52,050	83,560	827,110	
HANFORD: ER PROGRAM		705,050	2,920	59,050	1,641,660	2,408,690	
Overhead						290,100	
SUBTOTAL						2,698,790	
Profit						131,730	
SUBTOTAL						2,830,520	
Bond						13,440	
SUBTOTAL						2,843,960	
B&O Tax						9,220	
SUBTOTAL						2,853,190	
Material/Supply MPR						7,910	
TOTAL INCL INDIRECTS						2,861,100	
Subcontractor MPR						143,910	
SUBTOTAL						3,005,010	
Project Management/Construction Mgnt						442,540	
SUBTOTAL						3,447,550	
General & Admin/Common Support Pool						865,170	
SUBTOTAL						4,312,720	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Contingency						1,509,450	
TOTAL INCL OWNER COSTS						5,822,170	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis							
ANA:02.08 Sampling Rad Contaminated Media							
ANA:02.08.02 Ground Water Analysis Yr - 1							
Ground Water Analysis Yr - 1	9.00 EA	0	0	0	37,890	37,890	4210.00
ANA:02.08.03 Ground Water Analysis Yrs 2-12							
Ground Water Analysis Yrs 2-12	4.00 EA	0	0	0	16,840	16,840	4210.00
Sampling Rad Contaminated Media		0	0	0	54,730	54,730	
Monitoring, Sampling & Analysis		0	0	0	54,730	54,730	
Off-Site Analytical Services		0	0	0	54,730	54,730	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work							
SUB:01.02 Mobilize Personnel & Equipment							
SUB:01.02.02 Mobilize Trailers							
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	
SUB:01.04 Setup/Construct Temp Facilities							
SUB:01.04.01 Establish Facilities							
SUB:01.04.01.02 Setup Trailers		3,000	0	810	0	3,810	
Establish Facilities		3,000	0	810	0	3,810	
SUB:01.04.02 Construct Decon Area							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	4,350	1,070	3,770	0	9,190	382.93
SUB:01.04.03 Site Survey							
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,350	1,070	4,580	1,000	14,000	
SUB:01.05 Construct Temporary Utilities							
Construct Temporary Utilities		2,250	0	2,430	0	4,680	
SUB:01.06 Pre-Construction Submittals							
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work							
SUB:03.03 Earthwork							
Earthwork		0	0	0	5,000	5,000	
SUB:03.04 Roads/Parking/Curbs/Walks							
Roads/Parking/Curbs/Walks		0	0	0	19,720	19,720	
SUB:03.05 Fencing							
Fencing		0	0	0	7,650	7,650	
SUB:03.06 Electrical Distribution							
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	42,370	42,370	
SUB:06 Groundwater Collection & Control							
SUB:06.01 Extraction & Injection Wells							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction							
Well Drilling & Construction	8.00 EA	0	0	0	1,000,000	1,000,000	125000.00
SUB:06.01.04 Operations and Maintenance 3,6,9							
Operations and Maintenance 3,6,9		0	0	0	92,000	92,000	
SUB:06.01.9X Site Piping							
Site Piping		0	0	0	104,000	104,000	
Extraction & Injection Wells		0	0	0	1,196,000	1,196,000	
Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	
SUB:12 Chemical Treatment							
SUB:12.05 Ion Exchange							
SUB:12.05.04 Construction of Permanent Plant							
Construction of Permanent Plant	600.00 SF	0	0	0	234,000	234,000	390.00
Ion Exchange		0	0	0	234,000	234,000	
Chemical Treatment		0	0	0	234,000	234,000	
SUB:20 Site Restoration							
SUB:20.04 Revegetation and Planting							
Revegetation and Planting		0	0	0	10,000	10,000	
Site Restoration		0	0	0	10,000	10,000	
SUB:21 Demobilization							
SUB:21.02 Demobilize Personnel & Equipment							
SUB:21.02.02 Demobilize Trailers							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Demobilize Trailers		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	
SUB:21.04 Demobilize Temp Facilities							
SUB:21.04.02 Remove Decon Area							
Remove Decon Area	8.00 HR	1,450	360	0	0	1,810	225.72
Demobilize Temp Facilities		1,450	360	0	0	1,810	
SUB:21.05 Disconnect Temporary Utilities							
Disconnect Temporary Utilities		2,500	0	0	0	2,500	
SUB:21.06 Post-Construction Submittals							
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	1,503,370	1,526,850	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis							
WHC:02.08 Sampling Rad Contaminated Media							
WHC:02.08.02 Ground Water Analysis Yr - 1							
Ground Water Analysis Yr - 1	77.00 EA	0	0	0	31,610	31,610	410.47
WHC:02.08.03 Ground Water Analysis Yr 2 - 12							
Ground Water Analysis Yr 2 - 12	34.00 EA	0	0	0	14,380	14,380	423.01
WHC:02.08.04 Ground Water Monitor Smples 1-12							

U.S. Army Corps of Engineers
PROJECT BAREIX: HANFORD: ER PROGRAM - 100 BC-5 ION EXCHANGE
100 BC-5 ION EXCHANGE REMEDIATION MODEL
** PROJECT DIRECT SUMMARY - LEVEL 5 (Rounded to 10's) **

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Ground Water Monitor Smples 1-12	24.00 HR	660	0	0	0	660	27.62
Sampling Rad Contaminated Media		660	0	0	45,990	46,650	
Monitoring, Sampling & Analysis		660	0	0	45,990	46,650	
WHC:12 Chemical Treatment							
WHC:12.05 Ion Exchange							
WHC:12.05.06 Personnel Training							
Personnel Training		1,100	0	0	5,800	6,900	
WHC:12.05.08 Operation & Maintenance Yrs 1-12							
Operation & Maintenance Yrs 1-12	1.00 YR	539,520	0	52,050	31,770	623,330	623334.29
WHC:12.05.11 Prepare Annual Report (Yr 1)							
Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	0	0	90,150	43.34
WHC:12.05.12 Prepare Annual Report (Yrs 2-12)							
Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
Ion Exchange		690,840	0	52,050	37,570	780,460	
Chemical Treatment		690,840	0	52,050	37,570	780,460	
Westinghouse Hanford Company		691,500	0	52,050	83,560	827,110	
HANFORD: ER PROGRAM		705,050	2,920	59,050	1,641,660	2,408,690	
Overhead						290,100	
SUBTOTAL						2,698,790	
Profit						131,730	
SUBTOTAL						2,830,520	
Bond						13,440	
SUBTOTAL						2,843,960	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
B&O Tax						9,220	
SUBTOTAL						2,853,190	
Material/Supply MPR						7,910	
TOTAL INCL INDIRECTS						2,861,100	
Subcontractor MPR						143,910	
SUBTOTAL						3,005,010	
Project Management/Construction Mgnt						442,540	
SUBTOTAL						3,447,550	
General & Admin/Common Support Pool						865,170	
SUBTOTAL						4,312,720	
Contingency						1,509,450	
TOTAL INCL OWNER COSTS						5,822,170	

ANA:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA. Off-Site Analytical Services
ANA:02. Monitoring, Sampling & Analysis
ANA:02.08. Sampling Rad Contaminated Media
ANA:02.08.02. Ground Water Analysis Yr - 1

Assumptions:

1. Assume shake-down period with following sampling of treatment system:
   - First 2 days: Sample every four hours of influent and effluent (24 samples)
   - Next 5 days: 1 sample per day of influent and effluent (10 samples)
   - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)
2. Minimum 1 sample per ion exchange media replacement (60 days) of the influent and effluent for the 12-yr lifecycle. Default to 1 sampling effort every month (influent and effluent) (24 samples/yr)
3. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total samples = Yr 1 - 86
4. All on-site sample analyses performed by WHC mobile lab
5. 10% off-site verification analysis of reduced analyte list with CLP protocol. (10% of 86 = 9 ea)

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Analyze LLW Sample - Off-site Lab	9.00 EA	0.00 0	0.00 0	0.00 0	4210.00 37,890	4210.00 37,890	4210.00
	Ground Water Analysis Yr - 1	9.00 EA	0	0	0	37,890	37,890	4210.00

ANA:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA:02.08.03. Ground Water Analysis Yrs 2-12

Assumptions:

1. Minimum 1 sample per ion exchange media replacement (60 days) of influent and effluent for the 12-yr lifecycle. Default to 1 sampling effort every month (influent and effluent) (24 samples/yr)

2. Assume sampling of 7 monitoring wells on a semiannual basis for the 12 year lifecycle (14 samples/yr)

   - Total Samples Yrs 2 - 12 = 38/yr

3. All on-site sample analyses performed by WHC mobile lab

4. 10% off-site verification analysis of reduced analyte list with CLP protocol (10% of 38 = 4 ea)

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Analyze LLW Sample - Off-site Lab	4.00 EA	0.00 0	0.00 0	0.00 0	4210.00 16,840	4210.00 16,840	4210.00
	Ground Water Analysis Yrs 2-12	4.00 EA	0	0	0	16,840	16,840	4210.00
	Sampling Rad Contaminated Media		0	0	0	54,730	54,730	
	Monitoring, Sampling & Analysis		0	0	0	54,730	54,730	
	Off-Site Analytical Services		0	0	0	54,730	54,730	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB. Fixed Price Contractor							
SUB:01. Mobilization & Preparatory Work							
SUB:01.02. Mobilize Personnel & Equipment							
SUB:01.02.02. Mobilize Trailers							
FPC S3 Mobilize Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04. Setup/Construct Temp Facilities							
SUB:01.04.01. Establish Facilities							
SUB:01.04.01.02. Setup Trailers							
M FPC S3 Setup Field Office Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Storage Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Decon Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
Setup Trailers		3,000	0	809	0	3,809	
Establish Facilities		3,000	0	809	0	3,809	

SUB:01. Mobilization & Preparatory Work	QUANTY	UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.02. Construct Decon Area									
Work to be Performed: Construct decontamination area/pad for equipment and vehicles. Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Output: Assumed duration for this activity is 3 crew days.									
FPC S3 Laborer Group - 1				25.20	0.00	0.00	0.00	25.20	
- 3 ea	72.00	HR	0029	1,814	0	0	0	1,814	25.20
FPC S3 Laborer Group - 2				25.50	0.00	0.00	0.00	25.50	
- 3 ea	72.00	HR	0030	1,836	0	0	0	1,836	25.50
FPC S3 Group-6 Power Equipment Operator				29.10	0.00	0.00	0.00	29.10	
- 1 ea	24.00	HR	0039	698	0	0	0	698	29.10
FPC S3 Small Tools - 2 ea				0.00	1.39	0.00	0.00	1.39	
	48.00	HR	XMIXX020	0	67	0	0	67	1.39
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW				0.00	7.31	0.00	0.00	7.31	
4X4 3/4 TON PICK-UP - 1 ea	24.00	HR	T50F0004	0	175	0	0	175	7.31
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4				0.00	34.44	0.00	0.00	34.44	
HYDRO-SCOPIC - 1 ea	24.00	HR	H30BA001	0	826	0	0	826	34.44
M FPC S3 Construction Materials/Supplies				0.00	0.00	2156.00	0.00	2156.00	
Allowance	1.00	LS		0	0	2,156	0	2,156	2156.00
M FPC S3 Allowance for Tank				0.00	0.00	1617.00	0.00	1617.00	
Assume 1000 gal plastic tank for water collection	1.00	EA		0	0	1,617	0	1,617	1617.00
Construct Decon Area	24.00	HR		4,349	1,069	3,773	0	9,190	382.93

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.03. Site Survey							
FPC S3 Allowance for Site Survey		0.00	0.00	0.00	1000.00	1000.00	
Prepare site for construction	1.00 LS	0	0	0	1,000	1,000	1000.00
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,349	1,069	4,582	1,000	13,999	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.05. Construct Temporary Utilities							
M FPC S3 Allowance for Temporary Power		1.00	0.00	1.08	0.00	2.08	
	500.00 LF	500	0	539	0	1,039	2.08
M FPC S3 Allowance for Telephone		0.50	0.00	0.54	0.00	1.04	
	500.00 LF	250	0	270	0	520	1.04
M FPC S3 Allowance for Temporary Water		3.00	0.00	3.23	0.00	6.23	
and Sewer Service	500.00 LF	1,500	0	1,617	0	3,117	6.23
Construct Temporary Utilities		2,250	0	2,426	0	4,676	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.06. Pre-Construction Submittals							
FPC S3 Allowance for Pre-Construction Submittals by Fixed Price Contractor	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,599	1,819	7,007	11,000	29,424	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03. Site Work							
SUB:03.03. Earthwork							
FPC S3 Allowance for Site Preparation		0.00	0.00	0.00	5000.00	5000.00	
	1.00 LS	0	0	0	5,000	5,000	5000.00
Earthwork		0	0	0	5,000	5,000	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.04. Roads/Parking/Curbs/Walks							
FPC S3 Allowance for Access Road		0.00	0.00	0.00	10.00	10.00	
	400.00 SY	0	0	0	4,000	4,000	10.00
FPC S3 Allowance Gravel Parking Area		0.00	0.00	0.00	10.00	10.00	
	300.00 SY	0	0	0	3,000	3,000	10.00
FPC S3 Access Roads to Wells		0.00	0.00	0.00	2.12	2.12	
Assume 750 lf of road per well, 10 ft wide, native material 750 lf/well x 8 wells = 6000 lf	6000.00 LF	0	0	0	12,720	12,720	2.12
Roads/Parking/Curbs/Walks		0	0	0	19,720	19,720	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.05. Fencing							
FPC S3 Allowance for Permanent Fencing		0.00	0.00	0.00	21.00	21.00	
Assume 7 ft high security fence	350.00 LF	0	0	0	7,350	7,350	21.00
FPC S3 Allowance for Entrance Gate		0.00	0.00	0.00	300.00	300.00	
	1.00 EA	0	0	0	300	300	300.00
Fencing		0	0	0	7,650	7,650	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.06. Electrical Distribution							
FPC S3 Allowance for Site Electrical		0.00	0.00	0.00	10000.00	10000.00	
	1.00 LS	0	0	0	10,000	10,000	10000.00
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	42,370	42,370	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06. Groundwater Collection & Control							
SUB:06.01. Extraction & Injection Wells							
SUB:06.01.01. Well Drilling & Construction							
FPC S3 Drill/Install Extr/Inject Wells		0.00	0.00	0.00	700.00	700.00	
Note: 4 new extraction and 4 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and packaging of contaminated well cuttings, transport to the disposal facility, and associated disposal fees.	1200.00 LF	0	0	0	840,000	840,000	700.00
FPC S3 Allowance for Well Pumps-100 gpm		0.00	0.00	0.00	3000.00	3000.00	
	4.00 EA	0	0	0	12,000	12,000	3000.00
FPC S3 Allowance for Controls and		0.00	0.00	0.00	10000.00	10000.00	
Connections at Well Heads	8.00 EA	0	0	0	80,000	80,000	10000.00
FPC S3 Allowance for Water Level		0.00	0.00	0.00	1000.00	1000.00	
Monitoring Instrumentation Assume 5 peizometers per extraction well using well points	20.00 EA	0	0	0	20,000	20,000	1000.00
FPC S3 Allowance for Well Head Covers		0.00	0.00	0.00	1000.00	1000.00	
Assume manhole type cover at each well head	8.00 EA	0	0	0	8,000	8,000	1000.00
FPC S3 Allowance for Well Testing		0.00	0.00	0.00	5000.00	5000.00	
	8.00 EA	0	0	0	40,000	40,000	5000.00
Well Drilling & Construction	8.00 EA	0	0	0	1,000,000	1,000,000	125000.00

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.04. Operations and Maintenance 3,6,9							
FPC S3 Allowance for Well Workover		0.00	0.00	0.00	10000.00	10000.00	
Assume 1 workover every 3 yrs	8.00 EA	0	0	0	80,000	80,000	10000.00
for each well.							
Workovers in years 3,6,9.							
FPC S3 Allowance for Well Pump		0.00	0.00	0.00	3000.00	3000.00	
Replacement	4.00 EA	0	0	0	12,000	12,000	3000.00
Assume 1 pump replacement per							
production well every 3 years							
Replacement in years 3,6,9							
		-----------	-----------	-----------	-----------	-----------	
Operations and Maintenance 3,6,9		0	0	0	92,000	92,000	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.9X. Site Piping							
FPC S3 Allowance for Piping from Well Head to Treatment Plant Assume 750 lf of double wall PVC piping per extraction well 750 lf/well x 4 wells = 3000 lf	3000.00 LF	0.00 0	0.00 0	0.00 0	18.00 54,000	18.00 54,000	18.00
FPC S3 Allowance for Leak Detection	1.00 LS	0.00 0	0.00 0	0.00 0	5000.00 5,000	5000.00 5,000	5000.00
FPC S3 Allowance for Force Main Discharge Piping Assume 750 lf of single-wall PVC piping per injection well 750 lf/well x 4 wells = 3000 lf	3000.00 LF	0.00 0	0.00 0	0.00 0	15.00 45,000	15.00 45,000	15.00
Site Piping		0	0	0	104,000	104,000	
Extraction & Injection Wells		0	0	0	1,196,000	1,196,000	
Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	

SUB:12. Chemical Treatment	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:12. Chemical Treatment							
SUB:12.05. Ion Exchange							
SUB:12.05.04. Construction of Permanent Plant							
FPC S3 Excavate and Install Building Foundation	600.00 SF	0.00 0	0.00 0	0.00 0	20.00 12,000	20.00 12,000	20.00
FPC S3 Install Butler Building Assume a prefabricated heated building complete with frame, doors, roll up doors, gutters, insulation, and roof vent.	600.00 SF	0.00 0	0.00 0	0.00 0	20.00 12,000	20.00 12,000	20.00
FPC S3 Ion Exchange Equipment/Staging Assume 1 - 400 gpm treatment system, 15 resin vessels. Resin included in O&M	1.00 LS	0.00 0	0.00 0	0.00 0	156000.00 156,000	156000.00 156,000	156000.00
FPC S3 Allowance for Bldg Mechanical Includes equipment installation and connections, controls/instrumentation, interior piping (plastic), floor drains and piping, and HVAC.	600.00 SF	0.00 0	0.00 0	0.00 0	50.00 30,000	50.00 30,000	50.00
FPC S3 Allowance for Bldg Electrical Includes lighting, fixtures, motor starters, controllers, junction boxes, transformer, chart recorders, annunciators, panels, conduit, and wiring.	600.00 SF	0.00 0	0.00 0	0.00 0	40.00 24,000	40.00 24,000	40.00
Construction of Permanent Plant	600.00 SF	0	0	0	234,000	234,000	390.00
Ion Exchange		0	0	0	234,000	234,000	
Chemical Treatment		0	0	0	234,000	234,000	

SUB:20. Site Restoration	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:20. Site Restoration							
SUB:20.04. Revegetation and Planting							
FPC S3 Allowance for Site Restoration		0.00	0.00	0.00	2.00	2.00	
	5000.00 SY	0	0	0	10,000	10,000	2.00
Revegetation and Planting		0	0	0	10,000	10,000	
Site Restoration		0	0	0	10,000	10,000	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21. Demobilization							
SUB:21.02. Demobilize Personnel & Equipment							
SUB:21.02.02. Demobilize Trailers							
FPC S3 Demob Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Demobilize Trailers		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	

SUB:21. Demobilization	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.04. Demobilize Temp Facilities								
SUB:21.04.02. Remove Decon Area								
Work to be Performed: Remove decontamination area/pad for equipment and vehicles. Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Output: Assumed duration for this activity is 1 crew day.								
FPC S3 Group-6 Power Equipment Operator - 1 ea	8.00 HR	0039	29.10 233	0.00 0	0.00 0	0.00 0	29.10 233	29.10
FPC S3 Laborer Group - 1 - 3 ea	24.00 HR	0029	25.20 605	0.00 0	0.00 0	0.00 0	25.20 605	25.20
FPC S3 Laborer Group - 2 - 3 ea	24.00 HR	0030	25.50 612	0.00 0	0.00 0	0.00 0	25.50 612	25.50
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4 HYDRO-SCOPIC - 1 ea	8.00 HR	H30BA001	0.00 0	34.44 275	0.00 0	0.00 0	34.44 275	34.44
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW 4X4 3/4 TON PICK-UP - 1 ea	8.00 HR	T50F0004	0.00 0	7.31 58	0.00 0	0.00 0	7.31 58	7.31
FPC S3 Small Tools - 2 ea	16.00 HR	XMIXX020	0.00 0	1.39 22	0.00 0	0.00 0	1.39 22	1.39
Remove Decon Area	8.00 HR		1,450	356	0	0	1,806	225.72
Demobilize Temp Facilities			1,450	356	0	0	1,806	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.05. Disconnect Temporary Utilities							
M FPC S3 Remove Temporary Power		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Telephone		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Temporary Water		3.00	0.00	0.00	0.00	3.00	
and Sewer Service	500.00 LF	1,500	0	0	0	1,500	3.00
Disconnect Temporary Utilities		2,500	0	0	0	2,500	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.06. Post-Construction Submittals							
FPC S3 Allowance for Post-Construction Submittals by Fixed Price Contractor	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,106	0	10,000	15,056	
Fixed Price Contractor		13,548	2,925	7,007	1,503,370	1,526,850	

WHC:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC. Westinghouse Hanford Company
WHC:02. Monitoring, Sampling & Analysis
WHC:02.08. Sampling Rad Contaminated Media
WHC:02.08.02. Ground Water Analysis Yr - 1

Assumptions:

1. Assume shake-down period with following sampling of treatment system:
   - First 2 days: Sample every four hours of influent and effluent (24 samples)
   - Next 5 days: 1 sample per day of influent and effluent (10 samples)
   - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)

2. Minimum 1 sample per ion exchange media regeneration (60 days) of the influent and effluent for the 12-yr lifecycle. Default to 1 sampling effort every month (influent and effluent) (24 samples/yr)

3. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total samples Yr 1 = 86

4. 90% of samples analyzed by mobile lab (90% of 86 = 77)

5. HACH kit samples are taken 1 per shift for the 12-yr lifecycle plus an additional 48 samples during the shake-down period. (Yr 1 = 1,143 samples)

WHC	Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
		77.00 EA	0	0	0	30,800	30,800	400.00
WHC	HACH Kit Sampling		0.00	0.00	0.00	0.50	0.50	
		1143.00 EA	0	0	0	572	572	0.50
WHC	HACH Kit Replacement		0.00	0.00	0.00	235.00	235.00	
	Assume 1 per yr	1.00 EA	0	0	0	235	235	235.00
	Ground Water Analysis Yr - 1	77.00 EA	0	0	0	31,607	31,607	410.47

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC:02.08.03. Ground Water Analysis Yr 2 - 12

Assumptions:

1. Minimum 1 sample per ion exchange media replacement (60 days) of the influent and effluent for the 12-yr lifecycle. Default to 1 sampling event every month (influent and effluent) (24 samples/yr)

2. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr)

   - Total Samples Yrs 2-12 = 38

3. 90% of samples analyzed by mobile lab (90% of 38 = 34)

4. HACH kit samples are taken 1 per shift for the 12-yr lifecycle. (1,095 samples/yr)

		QUANTY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
		34.00 EA	0	0	0	13,600	13,600	400.00
WHC	HACH Kit Sampling		0.00	0.00	0.00	0.50	0.50	
		1095.00 EA	0	0	0	548	548	0.50
WHC	HACH Kit Replacement		0.00	0.00	0.00	235.00	235.00	
	Assume 1 per yr	1.00 EA	0	0	0	235	235	235.00
	Ground Water Analysis Yr 2 - 12	34.00 EA	0	0	0	14,383	14,383	423.01

WHC:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC:02.08.04. Ground Water Monitor Smples 1-12
Work to be Performed:
Take semiannual groundwater monitoring samples

Assumptions:
1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle. (14 samples/yr)

2. Assume 2 field technicians for 12 hours on a semiannual basis for the 12-year lifecycle. (24 hrs/yr)

WHC	Technician, Environmental		27.62	0.00	0.00	0.00	27.62	
	Restoration Ops - 2 ea	24.00 HR 85201	663	0	0	0	663	27.62
	Ground Water Monitor Smples 1-12	24.00 HR	663	0	0	0	663	27.62
	Sampling Rad Contaminated Media		663	0	0	45,989	46,652	
	Monitoring, Sampling & Analysis		663	0	0	45,989	46,652	

WHC:12. Chemical Treatment		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:12. Chemical Treatment									
WHC:12.05. Ion Exchange									
WHC:12.05.06. Personnel Training									
Note: This account to allow for operator time and an allowance for a 40 hour training course.									
WHC	Operator, Environmental Restoration Ops	40.00 HR	85302	27.62 1,105	0.00 0	0.00 0	0.00 0	27.62 1,105	27.62
WHC	Allowance for 40 hr Training	1.00 LS		0.00 0	0.00 0	0.00 0	800.00 800	800.00 800	800.00
WHC	Allowance for Maintenance Manuals	1.00 LS		0.00 0	0.00 0	0.00 0	5000.00 5,000	5000.00 5,000	5000.00
	Personnel Training			1,105	0	0	5,800	6,905	

WHC:12. Chemical Treatment		QUANTY	UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC:12.05.08. Operation & Maintenance Yrs 1-12

Assumptions:

1. Treatment facility will be fully staffed with 2 FTE's per shift, 3 shifts per day, 7 days per week.
   (365 days/yr x 24 hrs/day = 8760 hrs/yr)
2. Ion exchange media to be replaced every 60 days for Strontium 90 treatment.
3. 2 FTE crew will be composed of the following members:

   0.25 ea - supervisor
   1.00 ea - operator
   0.50 ea - TP tech support
   0.25 ea - maintenance engineer

	Description	QUANTY	UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Technician, Environmental Restoration Ops - Supervisor - 0.25 ea	2190.00	HR	85201	28.80 63,080	0.00 0	0.00 0	0.00 0	28.80 63,080	28.80
WHC	Operator, Environmental Restoration Ops - 1 ea	8760.00	HR	85302	27.62 241,984	0.00 0	0.00 0	0.00 0	27.62 241,984	27.62
WHC	Technician, Health Physics - 0.50 ea	4380.00	HR	33201	39.72 173,958	0.00 0	0.00 0	0.00 0	39.72 173,958	39.72
WHC	Skilled Craft, Environmental Restoration Ops - Maintenance - 0.25 ea	2190.00	HR	85301	27.62 60,496	0.00 0	0.00 0	0.00 0	27.62 60,496	27.62
WHC	Allowance for Electricity Wells: 1450 kW-hr/d Assume 24 hrs/day x 365 days/yr Total = 529,000 kW-hr/yr	529000	KWH		0.00 0	0.00 0	0.00 0	0.04 21,160	0.04 21,160	0.04
WHC	Allowance for Water Usage Water to flush flowlines	6000.00	GAL		0.00 0	0.00 0	0.00 0	0.02 120	0.02 120	0.02
M WHC S2	Ion Exchange Media Replacement Resin replacement once per year. 15 vessels x 45 cf/vessel x 6 changeouts (1 changeout every 2 mos) = 4050 cf/yr.	4050.00	CF		0.00 0	0.00 0	12.85 52,046	0.00 0	12.85 52,046	12.85
WHC	Disposal Fee for Ion Exchange Media Assume disposal at ERDF for years 1-12 of the 12-year	4050.00	CF		0.00 0	0.00 0	0.00 0	2.59 10,490	2.59 10,490	2.59

WHC:12. Chemical Treatment	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
lifecycle							
Operation & Maintenance Yrs 1-12	1.00 YR	539,519	0	52,046	31,770	623,334	623334.29

WHC:12. Chemical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
	WHC:12.05.11. Prepare Annual Report (Yr 1) Assume 2 FTE's for 6 months each year							
WHC	Engineer, Environmental Restoration Ops - 1 ea	1040.00 HR 85101	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
WHC	Scientist, Environmental Restoration Ops - 1 ea	1040.00 HR 85102	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
	Prepare Annual Report (Yr 1)	2080.00 HR	90,148	0	0	0	90,148	43.34

WHC:12. Chemical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:12.05.12. Prepare Annual Report (Yrs 2-12) Assume 66% of ø Year 1 Annual Report effort (2 FTE's for 4 months each year)								
WHC	Engineer, Environmental Restoration Ops - 1 ea	693.00 HR 85101	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
WHC	Scientist, Environmental Restoration Ops - 1 ea	693.00 HR 85102	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
	Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
	Ion Exchange		690,842	0	52,046	37,570	780,457	
	Chemical Treatment		690,842	0	52,046	37,570	780,457	
	Westinghouse Hanford Company		691,505	0	52,046	83,559	827,109	
	HANFORD: ER PROGRAM		705,053	2,925	59,053	1,641,659	2,408,690	

** LABOR BACKUP **

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
FPC	0029	Laborer Group - 1	15.84	0.0%	28.7%	3.57	1.25	25.20	HR	07/09/93	0.00	96
FPC	0030	Laborer Group - 2	16.09	0.0%	28.5%	3.57	1.25	25.50	HR	07/09/93	0.00	96
FPC	0039	Group-6 Power Equipment Operator	18.02	0.0%	27.4%	4.90	1.25	29.10	HR	07/09/93	0.00	32
WHC	33201	Technician, Health Physics	28.78	0.0%	38.0%	0.00	0.00	39.72	HR	01/07/94	0.00	4380
WHC	85101	Engineer, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC	85102	Scientist, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC	85201	Technician, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	2214
WHC	85301	Skilled Craft, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	2190
WHC	85302	Operator, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	8800

** EQUIPMENT BACKUP **

SRC	EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL	UOM	** TOTAL ** HOURS
MIL	H30BA001	HYD EXCAV,TRK MTD,.5 CY BKT,6X4	14.36	3.58	4.07	1.4	9.83	0.98	0.15	34.44	HR	32
MIL	T50F0004	TRK,HWY,4X4,F250,3/4T,8800 GVW	1.58	0.39	2.67	0.7	1.60	0.27	0.04	7.31	HR	32
MIL	XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39	HR	64

HANFORD: ER PROGRAM
100 BC-5 REVERSE OSMOSIS
1.4.10.1.1.10.5.2.4
REVERSE OSMOSIS REMEDIATION
PRELIMINARY COST MODEL

Designed By:
Estimated By: IT Corporation

Prepared By: USACE/CENPW COST ENG BRANCH
Project Time & Cost, Inc.

Date: 10/07/94

M C A C E S G O L D E D I T I O N
Composer GOLD Copyright (C) 1985, 1988, 1990, 1992
by Building Systems Design, Inc.
Release 5.20J

SUMMARY REPORTS SUMMARY PAGE

DETAILED ESTIMATE DETAIL PAGE

DETAILED ESTIMATE DETAIL PAGE

BACKUP REPORTS BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

Fri 07 Oct 1994

U.S. Army Corps of Engineers
PROJECT BARERO: HANFORD: ER PROGRAM - 100 BC-5 REVERSE OSMOSIS
100 BC-5 REVERSE OSMOSIS
** PROJECT OWNER SUMMARY - LEVEL 1 (Rounded to 10's) **

TIME 07:12:00
SUMMARY PAGE 1

		QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		122,090	0	0	0	42,730	164,820	
SUB	Fixed Price Contractor		5,063,620	369,640	814,990	1,593,300	2,744,550	10,586,100	
WHC	Westinghouse Hanford Company		1,495,900	0	224,380	438,670	755,630	2,914,590	
	HANFORD: ER PROGRAM		6,681,610	369,640	1,039,370	2,031,980	3,542,910	13,665,520	

** PROJECT OWNER SUMMARY - LEVEL 2 (Rounded to 10's) **

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis		122,090	0	0	0	42,730	164,820	
Off-Site Analytical Services		122,090	0	0	0	42,730	164,820	
SUB Fixed Price Contractor								
SUB:01 Mobilization & Preparatory Work		37,950	2,770	6,110	11,940	20,570	79,330	
SUB:03 Site Work		54,640	3,990	8,790	17,190	29,620	114,230	
SUB:06 Groundwater Collection & Control		1,542,380	112,590	248,250	485,320	835,990	3,224,540	
SUB:13 Physical Treatment		3,396,340	247,930	546,640	1,068,680	1,840,860	7,100,450	
SUB:20 Site Restoration		12,900	940	2,080	4,060	6,990	26,960	
SUB:21 Demobilization		19,420	1,420	3,130	6,110	10,520	40,590	
Fixed Price Contractor		5,063,620	369,640	814,990	1,593,300	2,744,550	10,586,100	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis		104,280	0	15,640	30,580	52,670	203,170	
WHC:13 Physical Treatment		1,391,620	0	208,740	408,090	702,960	2,711,420	
Westinghouse Hanford Company		1,495,900	0	224,380	438,670	755,630	2,914,590	
HANFORD: ER PROGRAM		6,681,610	369,640	1,039,370	2,031,980	3,542,910	13,665,520	

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services								
ANA:02 Monitoring, Sampling & Analysis								
ANA:02.08 Sampling Rad Contaminated Media								
ANA:02.08.02 Ground Water Analysis (YR 1)								
Ground Water Analysis (YR 1)	17.00 EA	71,570	0	0	0	25,050	96,620	5683.50
ANA:02.08.03 Ground Water Analysis (YRS 2-12)								
Ground Water Analysis (YRS 2-12)	12.00 EA	50,520	0	0	0	17,680	68,200	5683.50
Sampling Rad Contaminated Media		122,090	0	0	0	42,730	164,820	
Monitoring, Sampling & Analysis		122,090	0	0	0	42,730	164,820	
Off-Site Analytical Services		122,090	0	0	0	42,730	164,820	
SUB Fixed Price Contractor								
SUB:01 Mobilization & Preparatory Work								
SUB:01.02 Mobilize Personnel & Equipment								
SUB:01.02.02 Mobilize Trailers								
Mobilize Trailers		970	70	160	300	520	2,020	
Mobilize Personnel & Equipment		970	70	160	300	520	2,020	
SUB:01.04 Setup/Construct Temp Facilities								
SUB:01.04.01 Establish Facilities								
SUB:01.04.01.02 Setup Trailers		4,910	360	790	1,550	2,660	10,270	
Establish Facilities		4,910	360	790	1,550	2,660	10,270	
SUB:01.04.02 Construct Decon Area								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	11,850	870	1,910	3,730	6,420	24,780	1032.42
SUB:01.04.03 Site Survey								
Site Survey		1,290	90	210	410	700	2,700	
Setup/Construct Temp Facilities		18,050	1,320	2,910	5,680	9,790	37,740	
SUB:01.05 Construct Temporary Utilities								
Construct Temporary Utilities		6,030	440	970	1,900	3,270	12,610	
SUB:01.06 Pre-Construction Submittals								
Pre-Construction Submittals	4.00 EA	12,900	940	2,080	4,060	6,990	26,960	6740.25
Mobilization & Preparatory Work		37,950	2,770	6,110	11,940	20,570	79,330	
SUB:03 Site Work								
SUB:03.03 Earthwork								
Earthwork		6,450	470	1,040	2,030	3,490	13,480	
SUB:03.04 Roads/Parking/Curbs/Walks								
Roads/Parking/Curbs/Walks		25,430	1,860	4,090	8,000	13,780	53,170	
SUB:03.05 Fencing								
Fencing		9,870	720	1,590	3,100	5,350	20,630	
SUB:03.06 Electrical Distribution								
Electrical Distribution		12,900	940	2,080	4,060	6,990	26,960	
Site Work		54,640	3,990	8,790	17,190	29,620	114,230	
SUB:06 Groundwater Collection & Control								
SUB:06.01 Extraction & Injection Wells								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction								
Well Drilling & Construction	8.00 EA	1,289,620	94,140	207,560	405,790	698,990	2,696,100	337012.56
SUB:06.01.04 Operations and Maintenance 3,6,9								
Operations and Maintenance 3,6,9		118,640	8,660	19,100	37,330	64,310	248,040	
SUB:06.01.9X Site Piping								
Site Piping		134,120	9,790	21,590	42,200	72,690	280,390	
Extraction & Injection Wells		1,542,380	112,590	248,250	485,320	835,990	3,224,540	
Groundwater Collection & Control		1,542,380	112,590	248,250	485,320	835,990	3,224,540	
SUB:13 Physical Treatment								
SUB:13.21 Reverse Osmosis								
SUB:13.21.04 Construction of Permanent Plant								
Construction of Permanent Plant	600.00 SF	3,396,340	247,930	546,640	1,068,680	1,840,860	7,100,450	11834.08
Reverse Osmosis		3,396,340	247,930	546,640	1,068,680	1,840,860	7,100,450	
Physical Treatment		3,396,340	247,930	546,640	1,068,680	1,840,860	7,100,450	
SUB:20 Site Restoration								
SUB:20.04 Revegetation and Planting Yr 12								
Revegetation and Planting Yr 12		12,900	940	2,080	4,060	6,990	26,960	
Site Restoration		12,900	940	2,080	4,060	6,990	26,960	
SUB:21 Demobilization								
SUB:21.02 Demobilize Personnel & Equipment								
SUB:21.02.02 Demobilize Trailers-Yr 12								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Demobilize Trailers-Yr 12		970	70	160	300	520	2,020	
Demobilize Personnel & Equipment		970	70	160	300	520	2,020	
SUB:21.04 Demobilize Temp Facilities								
SUB:21.04.02 Remove Decon Area-Yr 12								
Remove Decon Area-Yr 12	8.00 HR	2,330	170	370	730	1,260	4,870	608.57
Demobilize Temp Facilities		2,330	170	370	730	1,260	4,870	
SUB:21.05 Disconnect Temporary Utilities								
Disconnect Temporary Utilities		3,220	240	520	1,010	1,750	6,740	
SUB:21.06 Post-Construction Submittals								
Post-Construction Submittals	4.00 EA	12,900	940	2,080	4,060	6,990	26,960	6740.25
Demobilization		19,420	1,420	3,130	6,110	10,520	40,590	
Fixed Price Contractor		5,063,620	369,640	814,990	1,593,300	2,744,550	10,586,100	
WHC Westinghouse Hanford Company								
WHC:02 Monitoring, Sampling & Analysis								
WHC:02.08 Sampling Rad Contaminated Media								
WHC:02.08.02 Ground Water Analysis-Yr 1								
Ground Water Analysis-Yr 1	149.00 EA	60,410	0	9,060	17,710	30,510	117,700	789.90
WHC:02.08.03 Ground Water Analysis-Yr 2-12								
Ground Water Analysis-Yr 2-12	106.00 EA	43,210	0	6,480	12,670	21,830	84,180	794.18
WHC:02.08.04 Ground Water Monitor Samples								

	QUANTITY UOM	CONTRACT COST	SUB MPR	PM/CM	G&A/CSP	CONTINGN	TOTAL COST	UNIT COST
Ground Water Monitor Samples	24.00 HR	660	0	100	190	330	1,290	53.82
Sampling Rad Contaminated Media		104,280	0	15,640	30,580	52,670	203,170	
Monitoring, Sampling & Analysis		104,280	0	15,640	30,580	52,670	203,170	
WHC:13 Physical Treatment								
WHC:13.21 Reverse Osmosis								
WHC:13.21.06 Personnel Training								
Personnel Training		6,900	0	1,040	2,020	3,490	13,450	
WHC:13.21.08 Operation and Maint (Yrs 1-12)								
Operation and Maint (Yrs 1-12)	1.00 YR	1,234,500	0	185,180	362,020	623,590	2,405,280	2405284.99
WHC:13.21.11 Prepare Annual Report (Yr 1)								
Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	13,520	26,440	45,540	175,640	84.44
WHC:13.21.12 Prepare Annual Report (Yrs 2-12)								
Prepare Annual Report (Yrs 2-12)		60,070	0	9,010	17,620	30,340	117,040	
Reverse Osmosis		1,391,620	0	208,740	408,090	702,960	2,711,420	
Physical Treatment		1,391,620	0	208,740	408,090	702,960	2,711,420	
Westinghouse Hanford Company		1,495,900	0	224,380	438,670	755,630	2,914,590	
HANFORD: ER PROGRAM		6,681,610	369,640	1,039,370	2,031,980	3,542,910	13,665,520	

** PROJECT INDIRECT SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		122,090	0	0	0	0	0	122,090	
SUB	Fixed Price Contractor		3,926,450	746,030	338,750	28,700	23,690	0	5,063,620	
WHC	Westinghouse Hanford Company		1,441,040	0	0	0	0	54,860	1,495,900	
	HANFORD: ER PROGRAM		5,489,580	746,030	338,750	28,700	23,690	54,860	6,681,610	
	Subcontractor MPR								369,640	
	SUBTOTAL								7,051,250	
	Project Management/Construction Mgnt								1,039,370	
	SUBTOTAL								8,090,630	
	General & Admin/Common Support Pool								2,031,980	
	SUBTOTAL								10,122,610	
	Contingency								3,542,910	
	TOTAL INCL OWNER COSTS								13,665,520	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis		122,090	0	0	0	0	0	122,090	
Off-Site Analytical Services		122,090	0	0	0	0	0	122,090	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work		29,420	5,590	2,540	220	180	0	37,950	
SUB:03 Site Work		42,370	8,050	3,660	310	260	0	54,640	
SUB:06 Groundwater Collection & Control		1,196,000	227,240	103,180	8,740	7,220	0	1,542,380	
SUB:13 Physical Treatment		2,633,600	500,380	227,210	19,250	15,890	0	3,396,340	
SUB:20 Site Restoration		10,000	1,900	860	70	60	0	12,900	
SUB:21 Demobilization		15,060	2,860	1,300	110	90	0	19,420	
Fixed Price Contractor		3,926,450	746,030	338,750	28,700	23,690	0	5,063,620	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis		104,280	0	0	0	0	0	104,280	
WHC:13 Physical Treatment		1,336,770	0	0	0	0	54,860	1,391,620	
Westinghouse Hanford Company		1,441,040	0	0	0	0	54,860	1,495,900	
HANFORD: ER PROGRAM		5,489,580	746,030	338,750	28,700	23,690	54,860	6,681,610	
Subcontractor MPR								369,640	
SUBTOTAL								7,051,250	
Project Management/Construction Mgnt								1,039,370	
SUBTOTAL								8,090,630	
General & Admin/Common Support Pool								2,031,980	
SUBTOTAL								10,122,610	
Contingency								3,542,910	
TOTAL INCL OWNER COSTS								13,665,520	

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services									
ANA:02 Monitoring, Sampling & Analysis									
ANA:02.08 Sampling Rad Contaminated Media									
ANA:02.08.02 Ground Water Analysis (YR 1)									
Ground Water Analysis (YR 1	17.00 EA	71,570	0	0	0	0	0	71,570	4210.00
ANA:02.08.03 Ground Water Analysis (YRS 2-1									
Ground Water Analysis (YRS	12.00 EA	50,520	0	0	0	0	0	50,520	4210.00
Sampling Rad Contaminated M		122,090	0	0	0	0	0	122,090	
Monitoring, Sampling & Anal		122,090	0	0	0	0	0	122,090	
Off-Site Analytical Service		122,090	0	0	0	0	0	122,090	
SUB Fixed Price Contractor									
SUB:01 Mobilization & Preparatory Work									
SUB:01.02 Mobilize Personnel & Equipment									
SUB:01.02.02 Mobilize Trailers									
Mobilize Trailers		750	140	60	10	0	0	970	
Mobilize Personnel & Equipm		750	140	60	10	0	0	970	
SUB:01.04 Setup/Construct Temp Facilities									
SUB:01.04.01 Establish Facilities									
SUB:01.04.01.02 Setup Trailers		3,810	720	330	30	20	0	4,910	
Establish Facilities		3,810	720	330	30	20	0	4,910	
SUB:01.04.02 Construct Decon Area									

** PROJECT INDIRECT SUMMARY - LEVEL 5 (Rounded to 10's) **

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	9,190	1,750	790	70	60	0	11,850	493.84
SUB:01.04.03 Site Survey									
Site Survey		1,000	190	90	10	10	0	1,290	
Setup/Construct Temp Facili		14,000	2,660	1,210	100	80	0	18,050	
SUB:01.05 Construct Temporary Utilities									
Construct Temporary Utiliti		4,680	890	400	30	30	0	6,030	
SUB:01.06 Pre-Construction Submittals									
Pre-Construction Submittals	4.00 EA	10,000	1,900	860	70	60	0	12,900	3224.04
Mobilization & Preparatory		29,420	5,590	2,540	220	180	0	37,950	
SUB:03 Site Work									
SUB:03.03 Earthwork									
Earthwork		5,000	950	430	40	30	0	6,450	
SUB:03.04 Roads/Parking/Curbs/Walks									
Roads/Parking/Curbs/Walks		19,720	3,750	1,700	140	120	0	25,430	
SUB:03.05 Fencing									
Fencing		7,650	1,450	660	60	50	0	9,870	
SUB:03.06 Electrical Distribution									
Electrical Distribution		10,000	1,900	860	70	60	0	12,900	
Site Work		42,370	8,050	3,660	310	260	0	54,640	
SUB:06 Groundwater Collection & Control									
SUB:06.01 Extraction & Injection Wells									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction									
Well Drilling & Constructio	8.00 EA	1,000,000	190,000	86,270	7,310	6,030	0	1,289,620	161202.22
SUB:06.01.04 Operations and Maintenance 3,6									
Operations and Maintenance		92,000	17,480	7,940	670	560	0	118,640	
SUB:06.01.9X Site Piping									
Site Piping		104,000	19,760	8,970	760	630	0	134,120	
Extraction & Injection Well		1,196,000	227,240	103,180	8,740	7,220	0	1,542,380	
Groundwater Collection & Co		1,196,000	227,240	103,180	8,740	7,220	0	1,542,380	
SUB:13 Physical Treatment									
SUB:13.21 Reverse Osmosis									
SUB:13.21.04 Construction of Permanent Plan									
Construction of Permanent P	600.00 SF	2,633,600	500,380	227,210	19,250	15,890	0	3,396,340	5660.56
Reverse Osmosis		2,633,600	500,380	227,210	19,250	15,890	0	3,396,340	
Physical Treatment		2,633,600	500,380	227,210	19,250	15,890	0	3,396,340	
SUB:20 Site Restoration									
SUB:20.04 Revegetation and Planting Yr 12									
Revegetation and Planting Y		10,000	1,900	860	70	60	0	12,900	
Site Restoration		10,000	1,900	860	70	60	0	12,900	
SUB:21 Demobilization									
SUB:21.02 Demobilize Personnel & Equipment									
SUB:21.02.02 Demobilize Trailers-Yr 12									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Demobilize Trailers-Yr 12		750	140	60	10	0	0	970	
Demobilize Personnel & Equi		750	140	60	10	0	0	970	
SUB:21.04 Demobilize Temp Facilities									
SUB:21.04.02 Remove Decon Area-Yr 12									
Remove Decon Area-Yr 12	8.00 HR	1,810	340	160	10	10	0	2,330	291.10
Demobilize Temp Facilities		1,810	340	160	10	10	0	2,330	
SUB:21.05 Disconnect Temporary Utilities									
Disconnect Temporary Utilit		2,500	480	220	20	20	0	3,220	
SUB:21.06 Post-Construction Submittals									
Post-Construction Submittal	4.00 EA	10,000	1,900	860	70	60	0	12,900	3224.04
Demobilization		15,060	2,860	1,300	110	90	0	19,420	
Fixed Price Contractor		3,926,450	746,030	338,750	28,700	23,690	0	5,063,620	
WHC Westinghouse Hanford Company									
WHC:02 Monitoring, Sampling & Analysis									
WHC:02.08 Sampling Rad Contaminated Media									
WHC:02.08.02 Ground Water Analysis-Yr 1									
Ground Water Analysis-Yr 1	149.00 EA	60,410	0	0	0	0	0	60,410	405.41
WHC:02.08.03 Ground Water Analysis-Yr 2-12									
Ground Water Analysis-Yr 2-	106.00 EA	43,210	0	0	0	0	0	43,210	407.61
WHC:02.08.04 Ground Water Monitor Samples									

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Ground Water Monitor Sample	24.00 HR	660	0	0	0	0	0	660	27.62
Sampling Rad Contaminated M		104,280	0	0	0	0	0	104,280	
Monitoring, Sampling & Anal		104,280	0	0	0	0	0	104,280	
WHC:13 Physical Treatment									
WHC:13.21 Reverse Osmosis									
WHC:13.21.06 Personnel Training									
Personnel Training		6,900	0	0	0	0	0	6,900	
WHC:13.21.08 Operation and Maint (Yrs 1-12)									
Operation and Maint (Yrs 1-	1.00 YR	1,179,650	0	0	0	0	54,860	1,234,500	1234500.32
WHC:13.21.11 Prepare Annual Report (Yr 1)									
Prepare Annual Report (Yr 1	2080.00 HR	90,150	0	0	0	0	0	90,150	43.34
WHC:13.21.12 Prepare Annual Report (Yrs 2-1									
Prepare Annual Report (Yrs		60,070	0	0	0	0	0	60,070	
Reverse Osmosis		1,336,770	0	0	0	0	54,860	1,391,620	
Physical Treatment		1,336,770	0	0	0	0	54,860	1,391,620	
Westinghouse Hanford Compan		1,441,040	0	0	0	0	54,860	1,495,900	
HANFORD: ER PROGRAM		5,489,580	746,030	338,750	28,700	23,690	54,860	6,681,610	
Subcontractor MPR								369,640	
SUBTOTAL								7,051,250	
Project Management/Construction Mgnt								1,039,370	
SUBTOTAL								8,090,630	
General & Admin/Common Support Pool								2,031,980	
SUBTOTAL								10,122,610	

** PROJECT INDIRECT SUMMARY - LEVEL 5 (Rounded to 10's) **

	QUANTITY UOM	TOTAL DIRECT	OVERHEAD	PROFIT	BOND	B&O TAX	MAT MPR	TOTAL COST	UNIT COST
Contingency								3,542,910	
TOTAL INCL OWNER COSTS								13,665,520	

** PROJECT DIRECT SUMMARY - LEVEL 1 (Rounded to 10's) **

		QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Off-Site Analytical Services		0	0	0	122,090	122,090	
SUB	Fixed Price Contractor		13,550	2,920	7,010	3,902,970	3,926,450	
WHC	Westinghouse Hanford Company		691,500	0	360,890	388,650	1,441,040	
	HANFORD: ER PROGRAM		705,050	2,920	367,900	4,413,710	5,489,580	
	Overhead						746,030	
	SUBTOTAL						6,235,610	
	Profit						338,750	
	SUBTOTAL						6,574,360	
	Bond						28,700	
	SUBTOTAL						6,603,070	
	B&O Tax						23,690	
	SUBTOTAL						6,626,750	
	Material/Supply MPR						54,860	
	TOTAL INCL INDIRECTS						6,681,610	
	Subcontractor MPR						369,640	
	SUBTOTAL						7,051,250	
	Project Management/Construction Mgnt						1,039,370	
	SUBTOTAL						8,090,630	
	General & Admin/Common Support Pool						2,031,980	
	SUBTOTAL						10,122,610	
	Contingency						3,542,910	
	TOTAL INCL OWNER COSTS						13,665,520	

** PROJECT DIRECT SUMMARY - LEVEL 2 (Rounded to 10's) **

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis		0	0	0	122,090	122,090	
Off-Site Analytical Services		0	0	0	122,090	122,090	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work		0	0	0	42,370	42,370	
SUB:06 Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	
SUB:13 Physical Treatment		0	0	0	2,633,600	2,633,600	
SUB:20 Site Restoration		0	0	0	10,000	10,000	
SUB:21 Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	3,902,970	3,926,450	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis		660	0	0	103,610	104,280	
WHC:13 Physical Treatment		690,840	0	360,890	285,040	1,336,770	
Westinghouse Hanford Company		691,500	0	360,890	388,650	1,441,040	
HANFORD: ER PROGRAM		705,050	2,920	367,900	4,413,710	5,489,580	
Overhead						746,030	
SUBTOTAL						6,235,610	
Profit						338,750	
SUBTOTAL						6,574,360	
Bond						28,700	
SUBTOTAL						6,603,070	
B&O Tax						23,690	
SUBTOTAL						6,626,750	
Material/Supply MPR						54,860	
TOTAL INCL INDIRECTS						6,681,610	
Subcontractor MPR						369,640	
SUBTOTAL						7,051,250	
Project Management/Construction Mgnt						1,039,370	
SUBTOTAL						8,090,630	
General & Admin/Common Support Pool						2,031,980	
SUBTOTAL						10,122,610	

** PROJECT DIRECT SUMMARY - LEVEL 2 (Rounded to 10's) **

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Contingency						3,542,910	
TOTAL INCL OWNER COSTS						13,665,520	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA Off-Site Analytical Services							
ANA:02 Monitoring, Sampling & Analysis							
ANA:02.08 Sampling Rad Contaminated Media							
ANA:02.08.02 Ground Water Analysis (YR 1)							
Ground Water Analysis (YR 1)	17.00 EA	0	0	0	71,570	71,570	4210.00
ANA:02.08.03 Ground Water Analysis (YRS 2-12)							
Ground Water Analysis (YRS 2-12)	12.00 EA	0	0	0	50,520	50,520	4210.00
Sampling Rad Contaminated Media		0	0	0	122,090	122,090	
Monitoring, Sampling & Analysis		0	0	0	122,090	122,090	
Off-Site Analytical Services		0	0	0	122,090	122,090	
SUB Fixed Price Contractor							
SUB:01 Mobilization & Preparatory Work							
SUB:01.02 Mobilize Personnel & Equipment							
SUB:01.02.02 Mobilize Trailers							
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	
SUB:01.04 Setup/Construct Temp Facilities							
SUB:01.04.01 Establish Facilities							
SUB:01.04.01.02 Setup Trailers		3,000	0	810	0	3,810	
Establish Facilities		3,000	0	810	0	3,810	
SUB:01.04.02 Construct Decon Area							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Construct Decon Area	24.00 HR	4,350	1,070	3,770	0	9,190	382.93
SUB:01.04.03 Site Survey							
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,350	1,070	4,580	1,000	14,000	
SUB:01.05 Construct Temporary Utilities							
Construct Temporary Utilities		2,250	0	2,430	0	4,680	
SUB:01.06 Pre-Construction Submittals							
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,600	1,820	7,010	11,000	29,420	
SUB:03 Site Work							
SUB:03.03 Earthwork							
Earthwork		0	0	0	5,000	5,000	
SUB:03.04 Roads/Parking/Curbs/Walks							
Roads/Parking/Curbs/Walks		0	0	0	19,720	19,720	
SUB:03.05 Fencing							
Fencing		0	0	0	7,650	7,650	
SUB:03.06 Electrical Distribution							
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	42,370	42,370	
SUB:06 Groundwater Collection & Control							
SUB:06.01 Extraction & Injection Wells							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.01 Well Drilling & Construction							
Well Drilling & Construction	8.00 EA	0	0	0	1,000,000	1,000,000	125000.00
SUB:06.01.04 Operations and Maintenance 3,6,9							
Operations and Maintenance 3,6,9		0	0	0	92,000	92,000	
SUB:06.01.9X Site Piping							
Site Piping		0	0	0	104,000	104,000	
Extraction & Injection Wells		0	0	0	1,196,000	1,196,000	
Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	
SUB:13 Physical Treatment							
SUB:13.21 Reverse Osmosis							
SUB:13.21.04 Construction of Permanent Plant							
Construction of Permanent Plant	600.00 SF	0	0	0	2,633,600	2,633,600	4389.33
Reverse Osmosis		0	0	0	2,633,600	2,633,600	
Physical Treatment		0	0	0	2,633,600	2,633,600	
SUB:20 Site Restoration							
SUB:20.04 Revegetation and Planting Yr 12							
Revegetation and Planting Yr 12		0	0	0	10,000	10,000	
Site Restoration		0	0	0	10,000	10,000	
SUB:21 Demobilization							
SUB:21.02 Demobilize Personnel & Equipment							
SUB:21.02.02 Demobilize Trailers-Yr 12							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Demobilize Trailers-Yr 12		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	
SUB:21.04 Demobilize Temp Facilities							
SUB:21.04.02 Remove Decon Area-Yr 12							
Remove Decon Area-Yr 12	8.00 HR	1,450	360	0	0	1,810	225.72
Demobilize Temp Facilities		1,450	360	0	0	1,810	
SUB:21.05 Disconnect Temporary Utilities							
Disconnect Temporary Utilities		2,500	0	0	0	2,500	
SUB:21.06 Post-Construction Submittals							
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,110	0	10,000	15,060	
Fixed Price Contractor		13,550	2,920	7,010	3,902,970	3,926,450	
WHC Westinghouse Hanford Company							
WHC:02 Monitoring, Sampling & Analysis							
WHC:02.08 Sampling Rad Contaminated Media							
WHC:02.08.02 Ground Water Analysis-Yr 1							
Ground Water Analysis-Yr 1	149.00 EA	0	0	0	60,410	60,410	405.41
WHC:02.08.03 Ground Water Analysis-Yr 2-12							
Ground Water Analysis-Yr 2-12	106.00 EA	0	0	0	43,210	43,210	407.61
WHC:02.08.04 Ground Water Monitor Samples							

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Ground Water Monitor Samples	24.00 HR	660	0	0	0	660	27.62
Sampling Rad Contaminated Media		660	0	0	103,610	104,280	
Monitoring, Sampling & Analysis		660	0	0	103,610	104,280	
WHC:13 Physical Treatment							
WHC:13.21 Reverse Osmosis							
WHC:13.21.06 Personnel Training							
Personnel Training		1,100	0	0	5,800	6,900	
WHC:13.21.08 Operation and Maint (Yrs 1-12)							
Operation and Maint (Yrs 1-12)	1.00 YR	539,520	0	360,890	279,240	1,179,650	1179645.26
WHC:13.21.11 Prepare Annual Report (Yr 1)							
Prepare Annual Report (Yr 1)	2080.00 HR	90,150	0	0	0	90,150	43.34
WHC:13.21.12 Prepare Annual Report (Yrs 2-12)							
Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
Reverse Osmosis		690,840	0	360,890	285,040	1,336,770	
Physical Treatment		690,840	0	360,890	285,040	1,336,770	
Westinghouse Hanford Company		691,500	0	360,890	388,650	1,441,040	
HANFORD: ER PROGRAM		705,050	2,920	367,900	4,413,710	5,489,580	
Overhead						746,030	
SUBTOTAL						6,235,610	
Profit						338,750	
SUBTOTAL						6,574,360	
Bond						28,700	
SUBTOTAL						6,603,070	

	QUANTITY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
B&O Tax						23,690	
SUBTOTAL						6,626,750	
Material/Supply MPR						54,860	
TOTAL INCL INDIRECTS						6,681,610	
Subcontractor MPR						369,640	
SUBTOTAL						7,051,250	
Project Management/Construction Mgnt						1,039,370	
SUBTOTAL						8,090,630	
General & Admin/Common Support Pool						2,031,980	
SUBTOTAL						10,122,610	
Contingency						3,542,910	
TOTAL INCL OWNER COSTS						13,665,520	

ANA:02. Monitoring, Sampling & Analysis		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA. Off-Site Analytical Services
ANA:02. Monitoring, Sampling & Analysis
ANA:02.08. Sampling Rad Contaminated Media
ANA:02.08.02. Ground Water Analysis (YR 1)

Assumptions:

1. Assume shake-down period with following sampling of treatment system:
   - First 2 days: Sample every four hours of influent and effluent (24 samples)
   - Next 5 days: 1 sample per day of influent and effluent (10 samples)
   - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)
2. 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr)
3. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total samples = 166
4. All on-site sample analyses performed by WHC mobile lab
5. 10% off-site verification analysis of reduced analyte list with CLP protocol. (10% of 166 = 17 ea)

		QUANTY UOM	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Analyze LLW Sample - Off-site Lab	17.00 EA	0.00 0	0.00 0	0.00 0	4210.00 71,570	4210.00 71,570	4210.00
	Ground Water Analysis (YR 1)	17.00 EA	0	0	0	71,570	71,570	4210.00

ANA:02. Monitoring, Sampling & Analysis		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

ANA:02.08.03. Ground Water Analysis (YRS 2-12)

Assumptions:

1. Assume 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr)

2. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total Samples = 118

3. All on-site sample analysis performed by WHC mobile lab

4. 10% off-site verification analysis of reduced analyte list with CLP protocol (10% of 118 = 12)

		QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
ANA	Analyze LLW Sample - Off-site Lab	12.00 EA		0.00 0	0.00 0	0.00 0	4210.00 50,520	4210.00 50,520	4210.00
	Ground Water Analysis (YRS 2-12)	12.00 EA		0	0	0	50,520	50,520	4210.00
	Sampling Rad Contaminated Media			0	0	0	122,090	122,090	
	Monitoring, Sampling & Analysis			0	0	0	122,090	122,090	
	Off-Site Analytical Services			0	0	0	122,090	122,090	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB. Fixed Price Contractor							
SUB:01. Mobilization & Preparatory Work							
SUB:01.02. Mobilize Personnel & Equipment							
SUB:01.02.02. Mobilize Trailers							
FPC S3 Mobilize Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Mobilize Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Mobilize Trailers		0	750	0	0	750	
Mobilize Personnel & Equipment		0	750	0	0	750	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04. Setup/Construct Temp Facilities							
SUB:01.04.01. Establish Facilities							
SUB:01.04.01.02. Setup Trailers							
M FPC S3 Setup Field Office Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Storage Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
M FPC S3 Setup Decon Trailer		1000.00	0.00	269.50	0.00	1269.50	
	1.00 EA	1,000	0	270	0	1,270	1269.50
Setup Trailers		3,000	0	809	0	3,809	
Establish Facilities		3,000	0	809	0	3,809	

SUB:01. Mobilization & Preparatory Work	QUANTY	UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.02. Construct Decon Area Work to be Performed: Construct decontamination area/pad for equipment and vehicles. Crew and Equipment: Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers Equipment: 1 backhoe, 1 pickup truck Output: Assumed duration for this activity is 3 crew days.									
FPC S3 Laborer Group - 1 - 3 ea	72.00	HR	0029	25.20 1,814	0.00 0	0.00 0	0.00 0	25.20 1,814	25.20
FPC S3 Laborer Group - 2 - 3 ea	72.00	HR	0030	25.50 1,836	0.00 0	0.00 0	0.00 0	25.50 1,836	25.50
FPC S3 Group-6 Power Equipment Operator - 1 ea	24.00	HR	0039	29.10 698	0.00 0	0.00 0	0.00 0	29.10 698	29.10
FPC S3 Small Tools - 2 ea	48.00	HR	XMIXX020	0.00 0	1.39 67	0.00 0	0.00 0	1.39 67	1.39
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW 4X4 3/4 TON PICK-UP - 1 ea	24.00	HR	T50F0004	0.00 0	7.31 175	0.00 0	0.00 0	7.31 175	7.31
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4 HYDRO-SCOPIC - 1 ea	24.00	HR	H30BA001	0.00 0	34.44 826	0.00 0	0.00 0	34.44 826	34.44
M FPC S3 Construction Materials/Supplies Allowance	1.00	LS		0.00 0	0.00 0	2156.00 2,156	0.00 0	2156.00 2,156	2156.00
M FPC S3 Allowance for Tank Assume 1000 gal plastic tank for water collection	1.00	EA		0.00 0	0.00 0	1617.00 1,617	0.00 0	1617.00 1,617	1617.00
Construct Decon Area	24.00	HR		4,349	1,069	3,773	0	9,190	382.93

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.04.03. Site Survey Prepare site for construction							
FPC S3 Allowance for Site Survey		0.00	0.00	0.00	1000.00	1000.00	
	1.00 LS	0	0	0	1,000	1,000	1000.00
Site Survey		0	0	0	1,000	1,000	
Setup/Construct Temp Facilities		7,349	1,069	4,582	1,000	13,999	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.05. Construct Temporary Utilities							
M FPC S3 Allowance for Temporary Power		1.00	0.00	1.08	0.00	2.08	
	500.00 LF	500	0	539	0	1,039	2.08
M FPC S3 Allowance for Telephone		0.50	0.00	0.54	0.00	1.04	
	500.00 LF	250	0	270	0	520	1.04
M FPC S3 Allowance for Temporary Water		3.00	0.00	3.23	0.00	6.23	
and Sewer Service	500.00 LF	1,500	0	1,617	0	3,117	6.23
Construct Temporary Utilities		2,250	0	2,426	0	4,676	

SUB:01. Mobilization & Preparatory Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:01.06. Pre-Construction Submittals							
FPC S3 Allowance for Pre-Construction Submittals by Fixed Price Contractor	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Pre-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Mobilization & Preparatory Work		9,599	1,819	7,007	11,000	29,424	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03. Site Work							
SUB:03.03. Earthwork							
FPC S3 Allowance for Site Preparation		0.00	0.00	0.00	5000.00	5000.00	
	1.00 LS	0	0	0	5,000	5,000	5000.00
Earthwork		0	0	0	5,000	5,000	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.04. Roads/Parking/Curbs/Walks							
FPC S3 Allowance for Access Road	400.00 SY	0.00 0	0.00 0	0.00 0	10.00 4,000	10.00 4,000	10.00
FPC S3 Allowance Gravel Parking Area	300.00 SY	0.00 0	0.00 0	0.00 0	10.00 3,000	10.00 3,000	10.00
FPC S3 Access Roads to Wells Assume 750 lf of road per well, 10 ft wide, native materials 750 lf/well x 8 wells =6000 lf	6000.00 LF	0.00 0	0.00 0	0.00 0	2.12 12,720	2.12 12,720	2.12
Roads/Parking/Curbs/Walks		0	0	0	19,720	19,720	

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.05. Fencing							
FPC S3 Allowance for Permanent Fencing		0.00	0.00	0.00	21.00	21.00	
Assume 7 ft high security fence	350.00 LF	0	0	0	7,350	7,350	21.00
FPC S3 Allowance for Entrance Gate		0.00	0.00	0.00	300.00	300.00	
	1.00 EA	0	0	0	300	300	300.00
Fencing		0	0	0	7,650	7,650	

Fri 07 Oct 1994 U.S. Army Corps of Engineers TIME 07:12:00

PROJECT BARERO: HANFORD: ER PROGRAM - 100 BC-5 REVERSE OSMOSIS

DETAILED ESTIMATE 100 BC-5 REVERSE OSMOSIS DETAIL PAGE 12

SUB. Fixed Price Contractor

SUB:03. Site Work	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:03.06. Electrical Distribution							
FPC S3 Allowance for Site Electrical		0.00	0.00	0.00	10000.00	10000.00	
	1.00 LS	0	0	0	10,000	10,000	10000.00
Electrical Distribution		0	0	0	10,000	10,000	
Site Work		0	0	0	42,370	42,370	

SUB:06. Groundwater Collection & Control	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06. Groundwater Collection & Control								
SUB:06.01. Extraction & Injectibn Wells								
SUB:06.01.01. Well Drilling & Construction								
FPC S3 Drill/Install Extr/Inject Wells Note: 4 new extraction and 4 new injection wells, 150 ft deep, 8 in diameter, screened for 50 ft. Unit cost is assumed to include handling and packaging of contaminated well cuttings, transport to the disposal facility, and associated disposal fees.	1200.00 LF		0.00 0	0.00 0	0.00 0	700.00 840,000	700.00 840,000	700.00
FPC S3 Allowance for Well Pumps-100 gpm	4.00 EA		0.00 0	0.00 0	0.00 0	3000.00 12,000	3000.00 12,000	3000.00
FPC S3 Allowance for Controls and Connections at Well Heads	8.00 EA		0.00 0	0.00 0	0.00 0	10000.00 80,000	10000.00 80,000	10000.00
FPC S3 Allowance for Water Level Monitoring Instrumentation Assume 5 peizometers per extraction well using well points	20.00 EA		0.00 0	0.00 0	0.00 0	1000.00 20,000	1000.00 20,000	1000.00
FPC S3 Allowance for Well Head Covers Assume manhole type cover at each well head	8.00 EA		0.00 0	0.00 0	0.00 0	1000.00 8,000	1000.00 8,000	1000.00
FPC S3 Allowance for Well Testing	8.00 EA		0.00 0	0.00 0	0.00 0	5000.00 40,000	5000.00 40,000	5000.00
Well Drilling & Construction	8.00 EA		0	0	0	1,000,000	1,000,000	125000.00

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.04. Operations and Maintenance 3,6,9							
FPC S3 Allowance for Well Workover		0.00	0.00	0.00	10000.00	10000.00	
Assume 1 every 3 yrs for each well for the 12-year lifecycle. Workovers performed in years 3, 6,9	8.00 EA	0	0	0	80,000	80,000	10000.00
FPC S3 Allowance for Well Pump		0.00	0.00	0.00	3000.00	3000.00	
Replacement Assume 1 pump replacement per production well every 3 years for the 12-year lifecycle. Pumps replaced in years 3,6,9	4.00 EA	0	0	0	12,000	12,000	3000.00
Operations and Maintenance 3,6,9		0	0	0	92,000	92,000	

SUB:06. Groundwater Collection & Control	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:06.01.9X. Site Piping							
FPC S3 Allowance for Piping from Well Head to Treatment Plant Assume 750 lf of double wall PVC piping per extraction well. 750 lf/well x 4 wells = 3000 lf	3000.00 LF	0.00 0	0.00 0	0.00 0	18.00 54,000	18.00 54,000	18.00
FPC S3 Allowance for Leak Detection	1.00 LS	0.00 0	0.00 0	0.00 0	5000.00 5,000	5000.00 5,000	5000.00
FPC S3 Allowance for Force Main Discharge Piping Assume 750 lf of single-wall PVC piping per injection well 750 lf/well x 4 wells = 3000 lf	3000.00 LF	0.00 0	0.00 0	0.00 0	15.00 45,000	15.00 45,000	15.00
Site Piping		0	0	0	104,000	104,000	
Extraction & Injection Wells		0	0	0	1,196,000	1,196,000	
Groundwater Collection & Control		0	0	0	1,196,000	1,196,000	

SUB:13. Physical Treatment	QUANTY UOM	CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:13. Physical Treatment SUB:13.21. Reverse Osmosis SUB:13.21.04. Construction of Permanent Plant								
FPC S3 Excavate and Install Building Foundation	600.00 SF		0.00 0	0.00 0	0.00 0	20.00 12,000	20.00 12,000	20.00
FPC S3 Install Butler Building Assume a prefabricated heated building complete with frame, doors, roll up doors, gutters, insulation, and roof vent.	600.00 SF		0.00 0	0.00 0	0.00 0	20.00 12,000	20.00 12,000	20.00
FPC S3 Reverse Osmosis Equipment/Staging Includes 1 - 400 gpm treatment system, 225-psi inlet pressure, 10% reject	1.00 LS		0.00 0	0.00 0	0.00 0	576000.00 576,000	576000.00 576,000	576000.00
FPC S3 Vapor Recompression Evaporator Capacity = 400 gpm x 0.1 = 40 gpm, includes startup boiler, 2% reject	1.00 LS		0.00 0	0.00 0	0.00 0	800000.00 800,000	800000.00 800,000	800000.00
FPC S3 Rotary Drum Filter/Dryer Liquid loading = 400 gpm x 0.1 x 0.02 = 0.8 gpm = 400 lbs/hr, Drying area = 70 sf	2.00 EA		0.00 0	0.00 0	0.00 0	585000.00 1,170,000	585000.00 1,170,000	585000.00
FPC S3 Steam Generator Evaporate 0.8 gpm = 400 lbs/hr 685,000 BTU/Hr	6.00 EA		0.00 0	0.00 0	0.00 0	1600.00 9,600	1600.00 9,600	1600.00
FPC S3 Allowance for Bldg Electrical Includes lighting, fixtures, motor starters, controllers, junction boxes, transformer, chart recorders, annunciators, panels, conduit, and wiring.	600.00 SF		0.00 0	0.00 0	0.00 0	40.00 24,000	40.00 24,000	40.00
FPC S3 Allowance for Bldg Mechanical Includes equipment installation and connections, controls/instrumentation, interior piping (plastic), floor drains and piping, and HVAC.	600.00 SF		0.00 0	0.00 0	0.00 0	50.00 30,000	50.00 30,000	50.00
Construction of Permanent Plant	600.00 SF		0	0	0	2,633,600	2,633,600	4389.33

SUB:13. Physical Treatment	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
Reverse Osmosis		0	0	0	2,633,600	2,633,600	
Physical Treatment		0	0	0	2,633,600	2,633,600	

SUB:20. Site Restoration	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:20. Site Restoration							
SUB:20.04. Revegetation and Planting Yr 12							
FPC S3 Allowance for Site Restoration		0.00	0.00	0.00	2.00	2.00	
	5000.00 SY	0	0	0	10,000	10,000	2.00
Revegetation and Planting Yr 12		0	0	0	10,000	10,000	
Site Restoration		0	0	0	10,000	10,000	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21. Demobilization							
SUB:21.02. Demobilize Personnel & Equipment							
SUB:21.02.02. Demobilize Trailers-Yr 12							
FPC S3 Demob Field Office Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Storage Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
FPC S3 Demob Decon Trailer		0.00	250.00	0.00	0.00	250.00	
	1.00 EA	0	250	0	0	250	250.00
Demobilize Trailers-Yr 12		0	750	0	0	750	
Demobilize Personnel & Equipment		0	750	0	0	750	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.04. Demobilize Temp Facilities							
SUB:21.04.02. Remove Decon Area-Yr 12							

Work to be Performed:
Remove decontamination area/pad for equipment and vehicles.

Crew and Equipment:
Fixed Price Contractor: 1 Group 6 Operator, 3 Group 1 Laborers, and 3 Group 2 Laborers
Equipment: 1 backhoe, 1 pickup truck

Output:
Assumed duration for this activity is 1 crew day.

Item	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
FPC S3 Group-6 Power Equipment Operator - 1 ea	8.00 HR 0039	29.10 233	0.00 0	0.00 0	0.00 0	29.10 233	29.10
FPC S3 Laborer Group - 1 - 3 ea	24.00 HR 0029	25.20 605	0.00 0	0.00 0	0.00 0	25.20 605	25.20
FPC S3 Laborer Group - 2 - 3 ea	24.00 HR 0030	25.50 612	0.00 0	0.00 0	0.00 0	25.50 612	25.50
FPC S3 HYD EXCAV,TRK MTD,.5 CY BKT,6X4 HYDRO-SCOPIC - 1 ea	8.00 HR H30BA001	0.00 0	34.44 275	0.00 0	0.00 0	34.44 275	34.44
FPC S3 TRK,HWY,4X4,F250,3/4T,8800 GVW 4X4 3/4 TON PICK-UP - 1 ea	8.00 HR T50F0004	0.00 0	7.31 58	0.00 0	0.00 0	7.31 58	7.31
FPC S3 Small Tools - 2 ea	16.00 HR XMIXX020	0.00 0	1.39 22	0.00 0	0.00 0	1.39 22	1.39
Remove Decon Area-Yr 12	8.00 HR	1,450	356	0	0	1,806	225.72
Demobilize Temp Facilities		1,450	356	0	0	1,806	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.05. Disconnect Temporary Utilities Yr 12							
M FPC S3 Remove Temporary Power		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Telephone		1.00	0.00	0.00	0.00	1.00	
	500.00 LF	500	0	0	0	500	1.00
M FPC S3 Remove Temporary Water		3.00	0.00	0.00	0.00	3.00	
and Sewer Service	500.00 LF	1,500	0	0	0	1,500	3.00
Disconnect Temporary Utilities		2,500	0	0	0	2,500	

SUB:21. Demobilization	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
SUB:21.06. Post-Construction Submittals Yr 12							
FPC S3 Allowance for Post-Construction Submittals by Fixed Price Contractor	4.00 EA	0.00 0	0.00 0	0.00 0	2500.00 10,000	2500.00 10,000	2500.00
Post-Construction Submittals	4.00 EA	0	0	0	10,000	10,000	2500.00
Demobilization		3,950	1,106	0	10,000	15,056	
Fixed Price Contractor		13,548	2,925	7,007	3,902,970	3,926,450	

WHC:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC. Westinghouse Hanford Company
WHC:02. Monitoring, Sampling & Analysis
WHC:02.08. Sampling Rad Contaminated Media
WHC:02.08.02. Ground Water Analysis-Yr 1

Assumptions:

1. Assume shake-down period with following sampling of treatment system:
   - First 2 days: Sample every four hours of influent anf effluent (24 samples)
   - Next 5 days: 1 sample per day of influent and effluent (10 samples)
   - Next 7 weeks: 1 sample per week of influent and effluent (14 samples)

2. 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle (104 samples/yr)

3. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle (14 samples/yr)

   - Total samples = 166

4. 90% of samples for analysis at mobile lab (90% of 166 = 149)

5. HACH kit samples are taken 1 per shift for the 12-yr lifecycle plus an additional 48 samples during the shake-down period. (1143 samples)

WHC	Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
		149.00 EA	0	0	0	59,600	59,600	400.00
WHC	HACH Kit Sampling		0.00	0.00	0.00	0.50	0.50	
		1143.00 EA	0	0	0	572	572	0.50
WHC	HACH Kit Replacement		0.00	0.00	0.00	235.00	235.00	
	Assume 1 per yr	1.00 EA	0	0	0	235	235	235.00
	Ground Water Analysis-Yr 1	149.00 EA	0	0	0	60,407	60,407	405.41

WHC:02. Monitoring, Sampling & Analysis		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC:02.08.03. Ground Water Analysis-Yr 2-12

Assumptions:

1. 1 sample per filter change out (1 week) of the influent and effluent for the 12-yr lifecycle
(104 samples/yr)

2. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle
(14 samples/yr)

- Total samples = 118

4. 90% of samples for analysis at mobile lab
(90% of 118 = 106)

5. HACH kit samples are taken 1 per shift for the 12-yr lifecycle
(1143 samples)

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Analyze LLW Sample - Mobile Lab		0.00	0.00	0.00	400.00	400.00	
		106.00 EA	0	0	0	42,400	42,400	400.00
WHC	HACH Kit Sampling		0.00	0.00	0.00	0.50	0.50	
		1143.00 EA	0	0	0	572	572	0.50
WHC	HACH Kit Replacement		0.00	0.00	0.00	235.00	235.00	
	Assume 1 per yr	1.00 EA	0	0	0	235	235	235.00
	Ground Water Analysis-Yr 2-12	106.00 EA	0	0	0	43,207	43,207	407.61

WHC:02. Monitoring, Sampling & Analysis	QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST

WHC:02.08.04. Ground Water Monitor Samples
Work to be Performed:
Take semiannual groundwater monitoring samples.

Assumptions:
1. Assume sampling of 7 monitoring wells on a semiannual basis for the 12-year lifecycle.
(14 samples/yr)

2. Assume 2 field Technicians for 6 hours on a semiannual basis for the 12-year lifecycle.
(24 hrs/yr)

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Technician, Environmental Restoration Ops - 2 ea	24.00 HR 85201	27.62 663	0.00 0	0.00 0	0.00 0	27.62 663	27.62
	Ground Water Monitor Samples	24.00 HR	663	0	0	0	663	27.62
	Sampling Rad Contaminated Media		663	0	0	103,613	104,276	
	Monitoring, Sampling & Analysis		663	0	0	103,613	104,276	

WHC:13. Physical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13. Physical Treatment								
WHC:13.21. Reverse Osmosis								
WHC:13.21.06. Personnel Training								
	Note: This account to allow for operator time and an allowance for a 40-hour training course.							
WHC	Operator, Environmental Restoration Ops	40.00 HR 85302	27.62 1,105	0.00 0	0.00 0	0.00 0	27.62 1,105	27.62
WHC	Allowance for 40 hr Training	1.00 LS	0.00 0	0.00 0	0.00 0	800.00 800	800.00 800	800.00
WHC	Allowance for Maintainence Manuals	1.00 LS	0.00 0	0.00 0	0.00 0	5000.00 5,000	5000.00 5,000	5000.00
	Personnel Training		1,105	0	0	5,800	6,905	

WHC:13. Physical Treatment

WHC:13.21.08. Operation and Maint (Yrs 1-12)

Assumptions:

1. Treatment facility will be fully staffed with 2 FTE's per shift, 3 shifts per day, 7 days per week.
(365 days/yr x 24 hrs/day = 8760 hrs)

2. Reverse Osmosis filters will be replaced every week for the 12-year lifecycle.

3. 2 FTE crew will be composed of the following members:

0.25 ea - supervisor
1.00 ea - operator
0.50 ea - TP tech support
0.25 ea - maintenance engineer

		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Operator, Environmental Restoration Ops - 1 ea	8760.00 HR 85302	27.62 241,984	0.00 0	0.00 0	0.00 0	27.62 241,984	27.62
WHC	Technician, Health Physics - 0.50 ea	4380.00 HR 33201	39.72 173,958	0.00 0	0.00 0	0.00 0	39.72 173,958	39.72
WHC	Skilled Craft, Environmental Restoration Ops - Maintenance - 0.25 ea	2190.00 HR 85301	27.62 60,496	0.00 0	0.00 0	0.00 0	27.62 60,496	27.62
WHC	Allowance for Electricity Wells: 1450 kW-hr/d RO System: 1567 kW-hr/d Recompr Evap: 4608 kW-hr/d (80 kW-hr/1000 gal) Rotary Filter: 4816 kW-hr/d Assume 24 hrs/day x 365 days/yr Total = 4,540,965 kW-hr/yr	4540965 KWH	0.00 0	0.00 0	0.00 0	0.04 181,639	0.04 181,639	0.04
WHC	RO System Chemicals Includes scale inhibitors $ 0.34/1000 gal, 400 gpm x 1440 m/d x 365 d/y = 210.2 MMgpy	******** GAL	0.00 0	0.00 0	0.00 0	0.00 63,060	0.00 63,060	0.00
M WHC S2	Reverse Osmosis Filter Replacement Assume replacement of 2 filters on a weekly basis for the 12-year lifecycle. (52 wk/yr x 2 filters/wk)	104.00 EA	0.00 0	0.00 0	3470.08 360,889	0.00 0	3470.08 360,889	3470.08

WHC:13. Physical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC	Disposal Fee for Reverse Osmosis Filters Assume disposal at ERDF for years 1-12 of the 12-year lifecycle. Assume each filter to be 40 cf	4160.00 CF	0.00 0	0.00 0	0.00 0	2.59 10,774	2.59 10,774	2.59
WHC	Disposal Fee - Evaporation Cake Assume disposal at ERDF for years 1-12 of the 12-year lifecycle. 400 gpm x 325 ppm = 16.6 cf/day, 16.6 cf/day x 365 days = 6055 cf/yr Assume 50% volume increase to stabilize evaporation cake 1.5 x 6055 cf/yr = 9083 cf/yr	9083.00 CF	0.00 0	0.00 0	0.00 0	2.59 23,525	2.59 23,525	2.59
WHC	Technician, Environmental Restoration Ops - Supervisor - 0.25 ea	2190.00 HR 85201	28.80 63,080	0.00 0	0.00 0	0.00 0	28.80 63,080	28.80
WHC	Allowance for Water Usage Assume 1000 gal per month usage for the 12-year lifecycle	12000 GAL	0.00 0	0.00 0	0.00 0	0.02 240	0.02 240	0.02
	Operation and Maint (Yrs 1-12)	1.00 YR	539,519	0	360,889	279,238	1,179,645	1179645.26

WHC:13. Physical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
WHC:13.21.11. Prepare Annual Report (Yr 1) Assume 2 FTE's for 6 months each year								
WHC	Engineer, Environmental Restoration Ops - 1 ea	1040.00 HR 85101	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
WHC	Scientist, Environmental Restoration Ops - 1 ea	1040.00 HR 85102	43.34 45,074	0.00 0	0.00 0	0.00 0	43.34 45,074	43.34
	Prepare Annual Report (Yr 1)	2080.00 HR	90,148	0	0	0	90,148	43.34

WHC:13. Physical Treatment		QUANTY UOM CREW ID	LABOR	EQUIPMNT	MAT/SUPP	UNIT CST	TOTAL COST	UNIT COST
	WHC:13.21.12. Prepare Annual Report (Yrs 2-12) Assume a 66% effort level of the year 1 report (2 FTE's for 4 months each year)							
WHC	Engineer, Environmental Restoration Ops - 1 ea	693.00 HR 85101	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
WHC	Scientist, Environmental Restoration Ops - 1 ea	693.00 HR 85102	43.34 30,035	0.00 0	0.00 0	0.00 0	43.34 30,035	43.34
	Prepare Annual Report (Yrs 2-12)		60,070	0	0	0	60,070	
	Reverse Osmosis		690,842	0	360,889	285,038	1,336,768	
	Physical Treatment		690,842	0	360,889	285,038	1,336,768	
	Westinghouse Hanford Company		691,505	0	360,889	388,651	1,441,044	
	HANFORD: ER PROGRAM		705,053	2,925	367,896	4,413,711	5,489,585	

** LABOR BACKUP **

SRC LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
FPC 0029	Laborer Group - 1	15.84	0.0%	28.7%	3.57	1.25	25.20	HR	07/09/93	0.00	96
FPC 0030	Laborer Group - 2	16.09	0.0%	28.5%	3.57	1.25	25.50	HR	07/09/93	0.00	96
FPC 0039	Group-6 Power Equipment Operator	18.02	0.0%	27.4%	4.90	1.25	29.10	HR	07/09/93	0.00	32
WHC 33201	Technician, Health Physics	28.78	0.0%	38.0%	0.00	0.00	39.72	HR	01/07/94	0.00	4380
WHC 85101	Engineer, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85102	Scientist, Environmental	35.38	0.0%	22.5%	0.00	0.00	43.34	HR	01/07/94	0.00	1733
WHC 85201	Technician, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	2214
WHC 85301	Skilled Craft, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	2190
WHC 85302	Operator, Environmental	22.55	0.0%	22.5%	0.00	0.00	27.62	HR	01/07/94	0.00	8800

Fri 07 Oct 1994

U.S. Army Corps of Engineers
PROJECT BARERO: HANFORD: ER PROGRAM - 100 BC-5 REVERSE OSMOSIS
100 BC-5 REVERSE OSMOSIS
** EQUIPMENT BACKUP **

TIME 07:12:00

BACKUP PAGE 2

SRC EQUIP ID	DESCRIPTION	DEPR	CAPT	FUEL	FOG	EQ REP	TR WR	TR REP	TOTAL UOM	** TOTAL ** HOURS
MIL H30BA001	HYD EXCAV,TRK MTD,.5 CY BKT,6X4	14.36	3.58	4.07	1.4	9.83	0.98	0.15	34.44 HR	32
MIL T50FO004	TRK,HWY,4X4,F250,3/4T,8800 GVW	1.58	0.39	2.67	0.7	1.60	0.27	0.04	7.31 HR	32
MIL XMIXX020	Small Tools	0.46	0.17	0.13	0.0	0.57			1.39 HR	64